ENHANCING SUCCESS FOR ADVANCED PLACEMENT STUDENTS THROUGH A PLC FEATURING RETRIEVAL PRACTICE

by

Thomas Keller

A dissertation submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctor of Education

Baltimore, Maryland

April 2021

Abstract

Advanced Placement (AP) expansion efforts have increased access to rigorous, college-preparatory curriculum and instruction for high school students, particularly for historically marginalized student populations. This broader AP recruitment pool includes students who have not previously experienced advanced academic courses and may have been denied sufficient preparation for the rigorous nature of AP courses and AP exams. Meanwhile, AP expansion has been associated with decreasing AP exam scores, and students who do not pass AP exams are not conferred the same academic and nonacademic benefits as their AP exam-passing peers. This mixed-methods, quasi-experimental study explored how to enhance AP teachers' capacities to prepare all AP students for academic success, particularly those entering AP courses with diverse academic backgrounds. The study implemented a 13-week, 7.5 total hour intervention—the AP professional learning community (PLC) featuring retrieval practice strategies, which science of learning research has shown may enhance durable, flexible learning. The study collected and analyzed quantitative and qualitative data to examine processes and outcomes. Participants reported that the AP PLC provided meaningful new learning and collaborative opportunities to incorporate retrieval strategies into their instructional practices and that the intervention was engaging due to active learning. The outcome evaluation of the intervention resulted in five salient findings: (a) AP teachers' knowledge of retrieval strategies increased for teachers in the treatment group compared to the control group, (b) AP teachers' self-efficacy for using retrieval strategies increased for teachers in the treatment group compared to the control group, (c) AP teachers increased their frequency of using retrieval strategies over the duration of the intervention, (d) AP teachers' perceptions of their students' preparedness for AP courses increased for teachers in the treatment group compared to the control group, and (e) the change

in AP students' unit test scores was greater, but not significantly, for students whose teachers participated in the AP PLC than for students whose teachers did not participate in the AP PLC. This study demonstrated that an inexpensive, short-term, situated professional learning intervention can leverage retrieval strategies to positively influence effective instructional practices and potentially enduring learning outcomes.

Keywords: Advanced Placement, professional learning community, retrieval practice, professional learning, teacher knowledge, teacher self-efficacy, instructional practices

Primary Reader and Adviser: Dr. Angela Broaddus

Secondary Reader and Co-Adviser: Dr. Karen Karp

JOHNS HOPKINS
SCHOOL *of* EDUCATION

Dissertation Approval Form

Student's Name: Thomas Keller III   Date: 04/05/2021

Dissertation Title:

Enhancing Success for Advanced Placement Students Through a PLC Featuring Retrieval Practice

The student has made all necessary revisions, and we have read, and approve this dissertation for submission to the Johns Hopkins Sheridan Libraries as partial fulfillment of the requirements for the Doctor of Education degree.

Angela Broaddus	AE Broaddus	April 5, 2021
Adviser	Signature	Date
Karen Karp	Karen Karp	April 7, 2021
Committee Member	Signature	Date
E. Juliana Paré-Blagoev	Juliana Paré-Blagoev	April 5, 2021
Committee Member	Signature	Date
Committee Member	Signature	Date

Dedication

This dissertation is dedicated to my supportive family:

To my mother and father, who instilled in me the value of education and becoming a life-long learner,

To my wife, Jessica, who ceaselessly encourages, loves, and supports me with unconditional optimism, wise insights, and selfless resolve,

To my sons, Beckett and Paxton, who are my heroes and role-models, and whose energy, passion, love, faith, compassion, and enduring hope compel me to become the best person I can be.

Acknowledgments

This dissertation is the product of the support and investment of many people, all of whom I am sincerely grateful.

I am deeply thankful for the guidance and wisdom provided by my doctoral committee. To my advisers, Dr. Angela Broaddus and Dr. Karen Karp, I deeply appreciate how you challenged me when I needed to be pushed and inspired me when I needed to be encouraged. Your endless and thoughtful feedback, patience, and guidance vitally supported me throughout my doctoral journey as I grew, and continue to grow, as a scholar practitioner. To Dr. Paré - Blagoev, thank you for being such an engaging and motivating professor and committee member. Your valuable expertise and keen perspectives indispensably shaped my dissertation from the very beginning up until the end.

I sincerely appreciate the insights and suggestions provided by instructors and teaching assistants throughout the Ed.D. program. Additionally, the feedback and viewpoints provided by fellow students throughout the program proved consequential in shaping my thinking about educational issues and scholarly skills. Particularly, the many hours spent in discussions and preparations with my comps study group—Sharmeen Mahmud, Laura Moore, and Richard Rose—invaluably supported me in becoming an inquisitive and critical consumer of research.

I am eternally grateful for the 35 teachers who volunteered to participate in my dissertation study in the midst of a pandemic. Those dedicated teachers valiantly committed their time and energy, despite the unprecedented challenges posed by the pandemic. Those highly-motivated teachers exemplified the hard work and professionalism that is characteristic of effective teachers who tirelessly strive to improve their craft for the benefit of their students.

I am beholden to every single one of the high school students who I have had the privilege of teaching for the past 15 years. Every day I am thankful for the opportunity to positively influence the lives of my students. Most of all, I appreciate the energy my students share; it is contagious and energizes me to continue to strive to become a better educator.

I am forever indebted to my loving and supportive family. To my parents, who have fervently supported all of my academic endeavors. To my wife, Jessica, who is the pillar in my life without whom I could not stand; I am forever grateful for your incessant championing of my aspirations. Most of all, to my sons, Beckett and Paxton, who each and every day for the past 1,000 days eagerly provided me with the motivation and encouragement to become the best scholar, practitioner, student, son, husband, father, and person that I can be.

Table of Contents

Abstract ii

Dedication v

Acknowledgments vi

List of Tables xiv

List of Figures xvii

Executive Summary 1

Chapter 1: Understanding the Problem of Practice 12

Problem of Practice 16

Theoretical Framework 18

Factors Related to Student Preparedness and Success in Advanced Placement Courses 19

Benefits of the Advanced Placement Program 22

Access to Advanced Placement Courses 26

Gender. 27

Race. 29

Socioeconomic status. 32

Urbanicity. 34

Success in Advanced Placement Courses 34

Gender. 35

Race. 36

Socioeconomic status. 37

Urbanicity. 39

Policies to Increase Advanced Placement Enrollment 39

Characteristics of Schools and Advanced Placement Teachers 43

School characteristics that support or hinder AP access and AP success. 43

Advanced Placement teacher background. 48

Advanced Placement teacher practices. 50

Advanced Placement Student-Level Factors 54

Student motivation to enroll in Advanced Placement courses. 54

Student attitudinal factors toward enrollment and success in Advanced Placement courses. 56

Family and peers. 60

Prior knowledge. 62

Summary 65

Chapter 2: Empirical Examination of the Problem of Practice and Underlying Causes 68

Context of the Study 68

Purpose of the Study 69

Research Questions 70

Method 72

Research Design. 72

Sample and participants. 73

Measures and instrumentation 75

Procedure 79

Findings and Discussion 81

Key Findings From the AP Enrollment and AP Exam Score Data 82

Descriptive statistics of Advanced Placement enrollment. 82

Descriptive statistics of Advanced Placement exam scores. 84

Change in Advanced Placement enrollment from 2014 to 2017. 86

Change in Advanced Placement exam pass rate from 2015 to 2017. 89

Key Observations and Discussion From the Qualitative Analysis 93

Efforts to increase advanced placement enrollment. 96
Advanced Placement exam pass rates.. 100
Differences in students' prior knowledge. 102
Collaboration... 107
Professional learning. 110
Instructional strategies. 114
Summary of the Findings 115
Limitations 118
Chapter 3: Intervention Literature Review 120
Theoretical Framework 123
Intervention Literature Synthesis 125
Professional Learning Framework. 125
Content focused. 127
Active learning. 128
Situated collaboration. 129
Modeling effective practice. 130
Coaching and expert support. 131
Feedback and reflection. 132
Sustained duration. 134
Summary of Professional Learning Literature. 136
Professional Learning Community (PLC) Intervention Literature 137
Summary of PLC Intervention Literature…………………………………….....142
Project-Based Learning (PBL) Intervention Literature 142
Summary of PBL Intervention Literature……………………………………146
Science of Learning Intervention Literature 146

Factors that influence how well students learn. 148

Retrieval practice intervention literature. 152

Summary of Science of Learning Intervention Literature. 166

Summary of Intervention Literature 167

Overview of the Proposed Solution and Conclusions.. 168

Chapter 4: Intervention Procedure and Program Evaluation Methodology............................... 170

Research Design.. 172

Process Evaluation 174

Research question 1. 175

Process evaluation components. 175

Improvement science. 177

Process evaluation indicators. 179

Outcome Evaluation.. 181

Research questions for the outcome evaluation. 181

Outcome evaluation design. 182

Strengths and limitations of the design. 185

Improvement science. 190

Method 191

Participants.. 191

Instrumentation. 194

Instrumentation for the process evaluation. 194

Instrumentation for outcome evaluation 196

Procedure 200

AP PLC Intervention... 200

Data Collection 203

Process evaluation data sources. 203
Outcome evaluation data sources. 204
Data Analysis 205
Process evaluation data sources. 205
Outcome evaluation data sources. 207
Chapter 5: Results and Discussion 209
Process of Implementation 209
Findings 210
Process Evaluation Results and Discussion. 210
Research question 1. 210
Ouctome Evaluation Results and Discussion. 229
Research question 2. 229
Research question 3. 245
Research question 4. 247
Research question 5. 256
Conclusions 258
Limitations 263
Implications for Practice 265
Future Research 266
References 268
Appendix A: Research Summary Plan Matrix 292
Appendix B: Semi-Structured Interview Questions for Advanced Placement Teachers 294
Appendix C: Semi-Structured Interview Questions for Principals 296
Appendix D: Recruitment Email to Advanced Placement Teachers 298
Appendix E: Recruitment Email to School Administrators 299

Appendix F: Needs Assessment Codebook 300

Appendix G: Initial Logic Model for the Advanced Placement Professional Learning Community 308

Appendix H: Data Collection Matrix for Process and Outcome Evaluations of the Advanced Placement Professional Learning Community 309

Appendix I: Process Evaluation Survey 312

Appendix J: Participant Recruitment Email for Potential Participants in the AP PLC 314

Appendix K: Participant Demographic Data Survey 315

Appendix L: Outcome Evaluation Survey 316

Appendix M: Semi-Structured Interview Protocol 320

Appendix N: Frequency of Use of Survey 321

Appendix O: Process Evaluation Codebook 322

Appendix P: Document Analysis of Lesson Elements Developed During the AP PLC Codebook 324

Appendix Q: Semi-Structured Interview Outcome Evaluation Codebook 326

List of Tables

Table 1.1 Definitions of Constructs and Variables 15

Table 1.2 Number of Students Taking Advanced Placement Exams and Total Number of Advanced Placement Exams Taken by Year 16

Table 1.3 Number of Male and Female Students Taking Advanced Placement Exams in 2018 in the United States 28

Table 1.4 Numbers of Advanced Placement Exams Taken by Race in the United States 31

Table 1.5 Measures of Student Outcomes at Fontana High School Corresponding With Advanced Placement Expansion That Began in 2008 47

Table 2.1 National, State, and County Demographic Comparisons From 5-Year (2013-2017) Data Profiles 69

Table 2.2 School Ranking Measures Compared to State Means, According to the State Department of Education Report Card Profiles 74

Table 2.3 Participants' Characteristics 74

Table 2.4 Sample Semi-Structured Interview Questions for Advance Placement Teachers and School Administrators 78

Table 2.5 Sample Semi-Structured Interview Questions to Address Each Construct 79

Table 2.6 Measures of Advanced Placement Enrollment From 2014 to 2017 by School 83

Table 2.7 Composite Measures of Advanced Placement Enrollment for All Five Schools 84

Table 2.8 Number of Advanced Placement Exams Taken and Passed in All Five Schools Per Year 85

Table 2.9 Composite Number of Advanced Placement Exams Taken and Passed 85

Table 2.10 Percent Change From Previous Year on Growth or Decline of Advanced Placement Enrollment by School 87

Table 2.11 Measures of Growth or Decline of Advanced Placement Enrollment as a Composite for All Five Schools 88

Table 2.12 Advanced Placement Exam Success in All Five Schools Per Year 90

Table 2.13 Advanced Placement Exam Success in All Five Schools Per Year 91

Table 2.14 Advanced Placement Exam Performance Aligned With Relative Advanced Placement Enrollment Per School 93

Table 2.15 Final Themes, Codes, and Definitions From the Qualitative Analysis 95

Table 3.1 Professional Learning Literature Reviewed 127

Table 3.2 Professional Learning Community Literature Reviewed 137

Table 3.3 Comparison of Advanced Placement Exam Performance Between Students Whose Teachers Did or Did Not Participate in the Advanced Placement Teacher Community 141

Table 3.4 Project-Based Learning Literature Reviewed.. 143

Table 3.5 Science of Learning Literature Reviewed 147

Table 4.1 Strengths of Mixed-Method Design 186

Table 4.2 Limitations to the Convergent Parallel Mixed-Method Design and Considerations to Mitigate the Limitations.. 187

Table 4.3 Threats to the Validity of Inferences for Mixed-Methods Design and Considerations to Minimize the Threats 188

Table 4.4 Threats to Validity of Inferences for Quasi-Experimental Design and Considerations to Mitigate.. 189

Table 4.5 Matching Criteria Data for the Treatment and Control Groups................................ 192

Table 4.6 Demographics for the Treatment and Control Groups 193

Table 4.7 Demographic Data for the Treatment and Control Schools 194

Table 4.8 Summary of the Process Evaluation Survey... 195

Table 4.9 A Priori Codes for Qualitative Document Analysis 196

Table 4.10 Summary of the Outcome Evaluation Survey for Outcome Evaluation Research Questions 2 and 4 198

Table 4.11 Summary of the Semi-Structured Interview Protocol for Outcome Evaluation Research Questions 2 and 4 199

Table 4.12 Scope and Sequence of the Advanced Placement Professional Learning Community (AP PLC) 201

Table 5.1 Proces Evaluation Survey Mean Composite Subscores for Meaningfulness and Engagement Indicators.. 211

Table 5.2 Final Themes, Frequency, and Definitions for the Meaningfulness of the New Learning Portion of the AP PLC 213

Table 5.3 Final Themes, Frequency, and Definitions for the Meaningfulness of the Collaboration Portion of the AP PLC 217

Table 5.4 Final Themes and Definitions from Document Analysis of Lesson Elements Produced During the AP PLC 220

Table 5.5 Final Themes, Frequency, and Definitions for the Engagement in the New Learning Portion of the AP PLC 224

Table 5.6 Final Themes, Frequency, and Definitions for the Engagement in the Collaborative Portion of the AP PLC 227

Table 5.7 Participants' Mean Knowledge Scores on Retrieval Practice Strategies 230

Table 5.8 Mean Change in Teachers' Knowledge of Effective Learning and Studying Strategies 233

Table 5.9 Themes for How the AP PLC Influenced Teachers' Knowledge of Retrieval Strategies 233

Table 5.10 Factor Loadings for Exploratory Factor Analysis of the Self-Efficacy Scale 237

Table 5.11 Participants' Mean Self-Efficacy Ratings for Using Retrieval Practice Strategies .. 238

Table 5.12 Mean Change in Teachers' Self-Efficacy for Using Effecitve Learning and Studying Strategies 241

Table 5.13 Themes for How the AP PLC Influenced Teachers' Self-Efficcy for Using Retrieval Strategies 241

Table 5.14 Participants' Frequency of Using Retrieval Practice Strategies Over Time During the AP PLC 246

Table 5.15 Factor Loadings for Exploratory Factor Analysis of the Perceptions of Preparedness Scale 248

Table 5.16 Participants' Mean Rating for Perceptions of Students' Preparedness for Success in AP Courses 249

Table 5.17 Mean Change in Teachers' Perceptions of Student Preparedness for AP Courses .. 251

Table 5.18 Themes for How the AP PLC Influenced Teachers' Perceptions of Their Students' Preparedness for AP Courses 252

Table 5.19 AP Students' Aggregate Mean Unit Exam Scores Completed Before and After the AP PLC 257

Table 5.20 Difference Between AP Students' Mean Unit Exam Scores Completed Before and After the AP PLC 257

List of Figures

Figure 1.1 Neal and Neal's (2013) nested model of ecological systems, focused on Person A (p. 729). 18

Figure 1.2 Nested EST framework of systems related to the AP student. 20

Figure 1.3 Conceptual framework of factors influencing student success in advanced placement courses. 21

Figure 3.1 Potential point of intervention within the conceptual framework of factors influencing student success in advanced placement courses and exams. 125

Figure 4.1 Theory of change for the Advanced Placement professional learning community resulting in outcomes. 174

Figure 5.1 Mean number of reported retrieval strategies used per week during the Advanced Placement professional learning community. 246

Executive Summary

Advanced Placement (AP) expansion efforts since the 1990s greatly increased participation in AP courses, which attempted to extend rigorous, college-preparatory curricula and instruction to many students (College Board, 2014; Judson & Hobson, 2015; Parker et al., 2013; Rowland & Shircliffe, 2016). However, AP expansion has been associated with a broadening AP recruitment pool, including students previously denied experiences in advanced academic courses, leading to many students facing disadvantages when they pursue AP courses (Kolluri, 2018) and decreasing AP exam pass rates (Judson & Hobson, 2015). Students who merely participate in AP courses, but are unsuccessful on AP exams, are not conferred the same academic and non-academic benefits as their AP exam passing peers (Ackerman, Kanfer, & Calderwood, 2013; Evans, 2019; McKillip & Rawls, 2013; Morgan & Klaric, 2007).

Factors Influencing AP Student Performance

Networked ecological systems theory (Neal & Neal, 2013) served as a framework for the initial investigation of factors related to the problem of practice. AP students were the focal individuals and various levels of factors were explored, which were conceived as existing among overlapping circles of systems and interactions surrounding AP students. The literature review revealed macrosystem level factors (i.e., benefits of the AP program, access to AP courses, and success in AP courses) that interacted with students' preparation for AP coursework and influenced students' potential for success in AP courses (Cisneros, Holloway-Libell, Gomez, Corley, & Powers, 2014; Judson & Hobson, 2015; McBride-Davis et al., 2015). Additionally, exosystem level factors (i.e., federal, state, and local policies intended to increase access to AP courses for traditionally underserved students) may have produced unintended, negative consequences (Klugman, 2013; Rowland & Shircliffe, 2016). Further, mesosystemic interactions (i.e., school characteristics, AP teacher background, AP teacher practices) have influenced students' preparedness for and success in AP courses (Flores & Gomez, 2011; Foust, Hertberg-Davis, & Callahan, 2009; Gagnon & Mattingly, 2016; Judson, 2017a; Vela et al., 2018). Finally, factors within students' microsystems (i.e., achievement motivation, self-efficacy, self-determination, family, peers, students' prior knowledge, and students' motivation to enroll in AP courses) have influenced students' preparedness for and success in AP courses (Bryan, Glynn, & Kittleson, 2011; Fenty & Allio, 2017; Shaunessy-Dedrick, Suldo, Roth, & Fefer, 2015; Smith, Hurwitz, & Avery, 2017; Walker & Pearsall, 2012).

Context

The context under study was a large, diverse public school district in a Mid-Atlantic state. Experienced AP teachers and high school principals throughout the district participated in the needs assessment. AP teachers in a treatment school and a control school participated in the intervention study. The treatment and control schools were matched according to publicly available data that ranked academic performance outcomes. The treatment and control schools generally served middle class families that spanned suburban and rural communities. The racial composition of the treatment and control schools differed but were matched as closely as possible within the district and included mostly White students.

Needs Assessment

The needs assessment examined changes in AP enrollment and AP exam scores in the district under study from 2014 to 2017. AP enrollment increased more than expected over the three-year period (X^2 [1, N = 5,113] = 9.23, p = .0024) and despite a decrease in AP exam scores during the three years, the change was not significant (X^2 [1, N = 4,097] = 0.73, p = 0.39). Importantly, qualitative analysis of semi-structured interviews with experienced AP teachers (n =

5) and principals (n = 2) in the district revealed salient perceptions: (a) current AP students are generally less prepared than AP students in the past, (b) all AP students, including those without advanced academic backgrounds, would be capable of success in AP courses if strategic learning supports were provided, (c) opportunities for collaboration among AP teachers is critical but insufficient, (d) AP teachers are differently prepared to effectively instruct AP courses, and (e) previous interventions to support AP students have not included supporting AP teachers and students by learning and engaging with effective learning and studying strategies.

Theoretical Framework

Learning develops from social interactions with others and is optimal in the learner's zone of proximal development (Vygotsky, 1978). In the intervention, the AP professional learning community (PLC), teachers engaged in new learning of retrieval-based effective learning and studying strategies, and collaborated to develop lesson elements that infused retrieval-based strategies. Teachers were scaffolded though their zones of proximal development for their capacity to support AP students for academic success by leveraging coaching from the PLC leader and collaboration among colleagues. Raphael, Vasquez, Fortune, Gavelek, and Au (2014) informed the AP PLC design and implementation with a sociocultural learning framework for professional learning, which included shared ownership, dialogue, active learning, systemic, and situated in each teacher's context.

Synthesis of Science of Learning Research Literature

Science of learning literature suggested that employing retrieval practice provides opportunities to: (a) enhance students' learning and retention of knowledge (Bobby & Meiyappan, 2018; Karpicke & Blunt, 2011; Roediger, Agarwal, McDaniel, & McDermott, 2011; Roediger & Karpicke, 2006), (b) facilitate transfer of stored information to novel applications

(Agarwal, Bain, & Chamberlain, 2012; Butler, 2010; McDaniel, Thomas, Agarwal, McDermott, & Roediger, 2013), (c) differentially positively influence students with relatively low working memory capacity (Agarwal, Finley, Rose, & Roediger, 2017), and (d) reduce students' test anxiety (Agarwal, D'Antonio, Roediger, McDermott, & McDaniel, 2014). Frameworks for infusing retrieval practice strategies into instruction (Firth, Smith, Harvard, & Boxer, 2018; Morano, 2019; Roediger & Pyc, 2012) informed the structure of the AP PLC intervention.

Intervention Study

AP teachers require enhanced supports to better prepare all AP students for academic success. This study included process and outcome evaluations of the AP PLC intervention, which aimed to provide AP teachers with capacities to better support all AP students, particularly those entering the AP program with diverse academic backgrounds.

Process Evaluation

The process evaluation of the AP PLC examined two indicators: (a) meaningfulness (i.e., participants' perceptions of how applicable the strategies and instructional techniques learned in the AP PLC were for their AP class) to measure the implementation of the AP PLC and (b) engagement (i.e., the active engagement of participants during the AP PLC) to measure participant responsiveness to the AP PLC. Next, the research question (RQ), research design, results, discussion, and conclusions are summarized.

Research question. The process evaluation addressed the following research question. RQ1: How did AP teachers describe their experience in the AP PLC?

Research design. The process evaluation used a convergent-parallel mixed methods design in which the quantitative and qualitative data were collected concurrently and analyzed separately, then mixed during interpretation (Creswell & Plano Clark, 2011). Data were collected at three times during the intervention (i.e., weeks 4, 8, and 13), which allowed for iterative improvements to the implementation of AP PLC. The quantitative data were obtained from a Likert-scale survey that measured the meaningfulness and engagement indicators; these data were analyzed with descriptive statistics and repeated measures ANOVA to compare differences in participants' perceptions of meaningfulness and engagement over time. The qualitative data were obtained from open-ended survey questions and document analysis of lesson plan elements participants developed during the AP PLC, which aimed to reveal how and why the quantitative findings were observed; these data were analyzed using thematic analysis (Braun & Clarke, 2006).

Results and discussion. Likert-scale rating ranged from 1 to 6; a rating of 6 indicated the highest possible level of meaningfulness and engagement. Teachers who participated in the AP PLC perceived the intervention as meaningful at week 4 ($\bar{x} = 5.39$, $SD = 0.41$), week 8 ($\bar{x} = 5.72$, $SD = 0.24$), and week 13 ($\bar{x} = 5.76$, $SD = 0.30$). Similarly, teachers who participated in the AP PLC perceived the intervention as engaging at week 4 ($\bar{x} = 5.46$, $SD = 0.56$), week 8 ($\bar{x} = 5.67$, $SD = 0.31$), and week 13 ($\bar{x} = 5.73$, $SD = 0.42$). Repeated measure ANOVA compared the meaningfulness scores collected at the three timepoints during the AP PLC ($F[2,40] = 6.73$, $p = .003$) and the engagement scores collected at the three timepoints during the AP PLC ($F[2,40] = 1.62$, $p = .21$). Qualitative analysis of open-ended survey questions suggested teachers found the modeling of the strategies and the research presented during the AP PLC as particularly meaningful. Document analysis of lesson plan elements that teachers developed during the AP PLC suggested participants effectively created and incorporated retrieval practice and complementary strategies into their AP courses. Finally, qualitative analysis of open-ended survey questions suggested that teachers found the applicability of information and strategies, modeling of strategies, research presented, active learning, and enjoyment of the collaborative activities particularly engaging.

Conclusions. AP teacher participants quantitatively rated the AP PLC as meaningful and engaging. Teachers described the most meaningful and engaging components of the AP PLC were the modeling of the strategies, the research presented that supported using the strategies to enhance durable and flexible learning, and the collaboration with the professional learning leader and colleagues.

Outcome Evaluation

The outcome evaluation of the AP PLC examined proximal and moderately distal outcomes of the intervention. These outcomes included measures of teachers' knowledge of retrieval strategies, teachers' self-efficacy for using retrieval strategies, teachers' frequency of using retrieval strategies, teachers' perceptions of students' preparedness for AP coursework, and an AP student performance measure; these outcomes are included in the RQs below. Then, the research design, results, discussion, and conclusions are summarized.

Research questions. The outcome evaluation aimed to reveal how the AP PLC intervention, which featured retrieval practice and associated learning and studying strategies informed by science of learning research, influenced AP teacher and student outcomes in the context of the following research questions. RQ2: To what extent did AP teachers' knowledge and self-efficacy of retrieval practice strategies increase in response to the AP PLC compared to a control group? RQ3: To what extent did AP teachers increase their use of retrieval practice strategies in their AP classes as a result of the AP PLC? RQ4: What were AP teachers' perceptions of how well students were prepared for success in AP courses after the AP PLC compared to a control group? RQ5: What was the difference between AP students' unit test scores before and after their teachers participated in the AP PLC compared to a control group?

Research design. This study employed a convergent parallel mixed-methods design, in which quantitative and qualitative data collection and analysis occur concurrently and independently prior to mixing the results (Creswell & Plano Clark, 2011). Equal priority was given to both the quantitative and qualitative strands of this study. This study employed a quasi-experimental design, which included a pre-test, a post-test, and a control group, and specifically used a nonequivalent comparison group design (Shadish, Cook, & Campbell, 2002). Sampling was purposive for AP teachers in the treatment group ($n = 22$) who volunteered to participate in the AP PLC—which included weekly, 30-minute new learning and collaborative sessions for 13 consecutive weeks—and AP teachers in the control group ($n = 13$) who volunteered to conduct business as usual.

Quantitative data analysis was conducted for all four RQs. For RQs 2 and 4, survey data were analyzed using t-tests to examine pre and post differences between the treatment and control groups. For RQ3, Pearson's correlation examined the relationship between time, in weeks, and mean number of strategies used by participants throughout the intervention. For RQ5, t-tests examined the differences from pre-test to post-test of AP students' aggregated mean unit exam scores between the treatment and control groups.

Qualitative data analysis was conducted for RQs 2 and 4. Interview data with participants in the treatment group ($n = 5$) were analyzed using thematic analysis (Braun & Clark, 2006). Deductive coding was conducted on a priori codes and inductive coding allowed new codes to emerge. The qualitative findings provided descriptive insight into how and why the changes in teachers' knowledge, self-efficacy, and perceptions of student preparedness were observed.

Results and discussion. For RQ2, a *t*-test compared the mean difference in composite teachers' knowledge from pre-test to post-test between the treatment and control groups, $t(33) = -5.16$, $p < .001$. This result indicated teachers in the treatment group demonstrated more gains in knowledge of effective learning and studying strategies than teachers in the control group. Qualitative analysis suggested these differential gains were due to the AP PLC prompting teachers to more intentionally and conscientiously incorporate retrieval and associated strategies into their AP classes.

Additionally for RQ2, a *t*-test compared the mean difference in composite teachers' self-efficacy from pre-test to post-test between the treatment and control groups, $t(33) = -4.40$, $p < .001$. This result indicated teachers in the treatment group demonstrated more gains in self-efficacy for using effective learning and studying strategies than teachers in the control group. Qualitative analysis suggested these differential gains were due to the AP PLC supporting teachers to (a) make subtle changes to their practice to incorporate retrieval opportunities for students, (b) utilize a range of low-tech and high-tech classroom activities that promote retrieval, and (c) teach their students how to use retrieval strategies when studying on their own.

For RQ3, AP teachers used retrieval strategies more frequently over the duration of the AP PLC (e.g., week 2 [$\bar{x} = 0.91$, $SD = 0.87$] and week 13 [$\bar{x} = 5.50$, $SD = 3.66$]). There was a strong, positive correlation between time and mean strategy use ($r = .865$, $n = 22$, $p < .001$).

For RQ4, a *t*-test compared the mean difference in composite teacher perceptions of student preparedness from pre-test to post-test between the treatment and control groups, $t(33) = -4.74$, $p < .001$. This result indicated teachers in the treatment group increased their perceptions of student preparedness more than the control group. Qualitative analysis suggested these differential gains were due to (a) the AP PLC supported teachers to employ various specific strategies and methods to help students become better learners, (b) teachers observed evidence of their students' academic growth that teachers attributed to retrieval strategies, and (c) challenges of virtual learning may have mitigated some potential benefits of using retrieval strategies.

For RQ5, the post-AP PLC aggregated mean unit test scores for the treatment group were greater than both of the pre-AP PLC aggregated mean unit test scores. However, the difference in mean pre-AP PLC and post-AP PLC test scores between the control and treatment groups was not significant, $t(33) = 0.995$, $p = .163$, when testing the same content but the mode of instruction varied (i.e., virtual and in-person). Similarly, the difference in mean pre-AP PLC and post-AP PLC test scores between the control and treatment groups was not significant, $t(33) = 1.36$, $p = .091$, when the mode of instruction was constant (i.e., virtual) but the tested content varied.

Conclusions. Five salient interpretations of the findings emerged: (a) the AP PLC enhanced AP teachers' knowledge of retrieval strategies, (b) the AP PLC enhanced AP teachers' self-efficacy for using retrieval strategies, (c) AP teachers significantly increased their use of retrieval practice in their AP classes as a result of the AP PLC, (d) the AP PLC enhanced AP teachers' perceptions of their students' preparedness for success in AP courses, and (e) the increase in students' unit test scores was greater, but not significantly, for students whose teachers participated in the AP PLC than for students whose teachers did not participate in the AP PLC.

Limitations

Several factors may have limited the potential to observe more compelling findings in this study: (a) the AP PLC was conducted virtually, which may have limited optimal engagement and collaboration among participants, (b) the virtual mode of instruction may have limited teachers' opportunities to infuse the strategies into their classes, (c) teachers' perceptions of student performance, capacity, and fidelity to using the strategies may have been limited by the virtual mode of instruction, (d) the sample size was not large (*N* = 35), and (e) the inability to obtain more distal outcomes (e.g., AP exam scores).

Although the AP PLC may be generalizable to various contexts, this study did not provide evidence to assume generalizability to: (a) an in-person AP PLC, (b) non-AP high school contexts, (c) grade level contexts other than 9-12, and (d) contexts with different demographics.

Implications for Research

The knowledge and application of effective learning and studying strategies are often underutilized in teachers' instructional practices (Karpicke, 2016; Roediger & Pyc, 2012). Roediger and Pyc (2012) suggested incorporating instructional practices that promote retrieval in students may be a practical and inexpensive way to enhance student learning. However, other researchers (e.g., Daniel, 2012) have recommended steps that first be taken before translating science of learning research to educational practice. These yet unrealized steps may be associated with the underutilization of retrieval strategies in teachers' practices. This evaluation of the AP PLC served to address some of Daniel's (2012) suggestions of steps required before translating science of learning research to practice; specifically, "careful experimentation in select classroom contexts" (p. 251) and "development and design of classroom/teacher-friendly methods…into everyday practice" (p. 251). Thus, the evaluation of the AP PLC has taken steps to help bridge the gap between research and instructional practice.

Implications for Practice

Notably, the AP PLC was an inexpensive and relatively short-term professional learning experience that positively influenced various teacher and student outcomes. The AP PLC may serve as a model of a way to produce positive outcomes for teachers and students for educational contexts that have limited financial resources and limited time for professional learning. These positive outcomes may be achievable because they require only modest changes to teachers' instructional behaviors, yet modest changes to instruction may translate into substantial growth in student learning. Such modest changes in teachers' instructional behaviors may be transferable to all future classes taught. Additionally, this study shows how a local, contextualized, user-focused, grassroots professional learning experience can lead to measurable positive outcomes and may inspire other experienced teachers to conduct design research. The benefits to students' learning and studying capacities resulting from the AP PLC may extend to future courses taken by AP students.

Chapter 1: Understanding the Problem of Practice

Advanced Placement (AP) courses provide high school students opportunities to engage in rigorous curricula and earn college credit during high school. However, some students who enroll in these courses do not earn high enough scores on end-of-course AP exams to be eligible for college credit. This study explores factors that contribute to students' inadequate preparation for AP coursework and how that under-preparedness may influence success and potential benefits from AP course participation. Success in AP courses is commonly measured by course grade (Sadler & Tai, 2007) and AP exam score (Burney, 2010; Cisneros et al., 2014; Gagnon & Mattingly, 2016), while there are other benefits both academic (Fischer et al., 2018b; Hallett & Venegas, 2011; Parker et al., 2013; Rowland & Shircliffe, 2016) and nonacademic (Foust et al., 2009; Shaunessy-Dedrick et al., 2015). Students who are underprepared for advanced academic coursework, even when they have access to AP courses, are not able to receive all the potential benefits of AP courses.

Historically, the purpose of the AP program during its inception in the 1950s was to identify America's most academically elite high school students and provide them with college level classes to expedite their college education—accomplished by earning college credit for completing AP courses while in high school (Rothschild, 1999). Students who earn AP credit in high school gain future benefits of reduced time to college degree, increased opportunities to double major, and greater flexibility to enroll in more advanced college coursework (Evans, 2019). Over the years, the purpose of the AP program has changed substantially; beginning in the 1990s the major intent of the AP program has been to provide a maximum number of students with rigorous, advanced-level coursework and improved learning outcomes (College Board, 2014; Judson & Hobson, 2015). This shift in purpose of the AP program has resulted in drastic increases in AP course enrollment and AP exam taking since the 1990s (College Board, 2018). For example, the number of students who took at least one AP exam increased from 292,164 in 1987 to 2,808,990 in 2018; the number of total AP exams taken increased from 424,844 in 1988 to 5,090,324 total exams in 2018 (College Board, 2018). This increase in AP course enrollment and AP exam taking has correlated with a decrease in AP exam performance overall (Judson & Hobson, 2015). Specifically, regression analysis indicated a downward trend in the percent of students earning a passing AP exam score (3 or higher) from 65.5% in 1992 to 59.2% in 2012 ($R^2 = 0.84$, $p < 0.001$; Judson & Hobson, 2015). A 2000 recommendation from then United States Secretary of Education, Richard Riley, and College Board president, Gaston Caperton, that all United States high schools offer at least ten AP courses may have stimulated efforts of rapid AP expansion (Lichten, 2010). Beginning in the early 2000s, many states, such as California (Flores & Gomez, 2011; Hallett & Venegas, 2011; Klugman, 2013) and Florida (McBride-Davis et al., 2015; Rowland & Shircliffe, 2016) began efforts to expand AP course offerings and AP enrollment in response to a national call for more students to engage in rigorous coursework (Flores & Gomez, 2011). These efforts toward expanding AP programs included state mandates to establish AP courses in high schools (Arce-Trigatti, 2018), to provide financial incentives (McBride-Davis et al., 2015), and in some districts to lower or eliminate prerequisite requirements for students to enroll in AP courses to increase AP access (Flores & Gomez, 2011; Hallett & Venegas, 2011; Rowland & Shircliffe, 2016). Although increasing access to AP courses, particularly for historically underserved students (i.e., minority students and students of low socioeconomic backgrounds), has been successful, the influx of students new to advanced academic coursework may have inadvertently created a wave of students under-prepared for AP coursework (Hallett & Venegas, 2011; Judson & Hobson, 2015; Kolluri, 2018).

Therefore, increased AP access needs to be coupled with AP courses that provide improved opportunities for success for all students (Flores & Gomez, 2011; Hallett & Venegas, 2011; Judson & Hobson, 2015; Klugman, 2013; Rodriguez & McGuire, 2019; Rowland & Shircliffe, 2016). This recommendation from the literature establishes the rationale for the problem of practice; students who enroll in AP courses without previous experience in advanced academic coursework are likely to need additional academic supports to succeed in AP courses and achieve passing scores on AP exams (Judson & Hobson, 2015; Kolluri, 2018). Table 1.1 defines the major constructs and variables investigated in this study.

Table 1.1

Definitions of Constructs and Variables

Construct or Variable	Definition	Source
AP access	The opportunity for students to participate in at least one AP course at the school they attend	Gagnon & Mattingly, 2016
AP enrollment	The percent of high school students enrolled in at least one AP course	Gagnon & Mattingly, 2016
	The total number of students enrolled in at least one AP course	Klugman, 2013
AP participation	A student characteristic of being enrolled in an AP course	Judson, 2017b
AP success	AP course grades	Sadler & Tai, 2007
	AP exam scores (1, 2, 3, 4, 5) 1 = lowest possible score 5 = highest possible score	Cisneros et al., 2014; Gagnon & Mattingly, 2016; Judson & Hobson, 2015; Parker et al., 2013
AP exam pass rate	The percent of students who earn a 3, 4, or 5 on the AP exam	Cisneros et al., 2014; Judson & Hobson, 2015
AP teacher background	The training, qualifications, knowledge, and preparation a teacher possesses to instruct an AP course	Milewski, 2002
Teacher practices	Any pedagogical and instructional methods and strategies used in teaching an AP class	Fischer, Eisenkraft, Fishman, Hubner, & Lawrenz, 2018a
Student achievement motivation	The internal drive that begins, directs, and maintains goal-oriented behavior	Bryan et al., 2011
Student self-efficacy toward success in an AP course	Students' belief in themselves that they can achieve well and succeed in an AP course	Bryan et al., 2011
Student self-determination	Students' perceptions of the control they possess over their own learning	Bryan et al., 2011
Student prior knowledge	The content-specific understanding a student possesses when entering an AP course	National Research Council, 2002

Problem of Practice

A primary goal of the AP program is to increase equitable access to AP coursework for all students (College Board, 2014; Judson & Hobson, 2015). Efforts to increase AP access and participation for historically underrepresented students since the 1990s have been successful (Judson & Hobson, 2015; Parker et al., 2013; Rowland & Shircliffe, 2016). However, simultaneously, AP enrollment has increased even more in affluent schools than schools serving other populations, thereby doing little to bridge equity gaps in access to AP courses (Klugman, 2013). Overall, the growth of the AP program is evident; Table 1.2 shows the number of students who took at least one AP exam and the total number of AP exams taken in each academic year globally, as some students took more than one AP exam each year (College Board, 2018).

Table 1.2

Number of Students Taking AP Exams and Total Number of AP Exams Taken by Year

Academic year	Number of students who took at least one AP exam	Total number of AP exams taken
1957-1958	3,715	6,800
1967-1968	46,917	60,674
1977-1978	93,313	122,561
1987-1988	292,164	424,844
1997-1998	635,168	1,016,657
2007-2008	1,580,821	2,736,445
2017-2018	2,808,990	5,090,324

Furthermore, efforts to increase AP enrollment have resulted in AP courses with diverse student academic profiles, contributing to a growing need for improvements in effectively teaching AP students whose academic backgrounds have not included advanced pre-AP courses (Kolluri, 2018).

High school students who do not have the benefit of having previously taken advanced academic courses face disadvantages when they move up to rigorous AP courses, resulting in poorer student outcomes in AP courses (Kolluri, 2018). Student outcomes in AP courses, as measured by AP exam scores, have decreased globally for all students from 1992-2012 (Judson & Hobson, 2015). Furthermore, AP exam pass rates for White and Asian students have held constant, while pass rates for Black, Hispanic, and American Indian students have dropped; seemingly, the widening diversity of the recruitment pool for AP courses has corresponded with a reduced pass rate for traditionally underrepresented students (Cisneros et al., 2014; Judson & Hobson, 2015; McBride-Davis et al., 2015). Students who merely take AP courses but fail AP exams miss out on benefits conferred to AP exam passers, such as higher future SAT scores (McKillip & Rawls, 2013), reduced time to college degree, lower tuition due to less time enrolled in college, higher rates of double majoring and taking more advanced courses (Evans, 2019), higher college grades (Ackerman et al., 2013; Morgan & Klaric, 2007), and improved college graduation rate (Ackerman et al., 2013; Smith et al., 2017). Therefore, there is a need to better understand whether students new to advanced academic courses underperform in AP courses due to differences in pre-AP coursework and to explore the factors related to performance of students new to advanced academic courses. In addition to AP students new to advanced coursework, all AP students may benefit from research leading to an improved understanding of factors related to student preparedness and success in AP courses.

Theoretical Framework

This study employs the networked ecological systems theory (EST) presented by Neal and Neal (2013) to investigate factors related to preparedness and success in Advanced Placement courses. Neal and Neal (2013) offer an alternate perspective to Bronfenbrenner's (1994, 2006) EST which conceptualizes smaller level ecological systems nested within larger level systems. Bronfenbrenner's (1994, 2006) EST can be visualized as systems represented by concentric circles nested within one another, whereas Neal and Neal's (2013) EST model shown in Figure 1.1 can be visualized as systems represented by circles in overlapping arrangements showing the relationships and mesosystemic interconnectedness between the systems, but not necessarily all nested hierarchically.

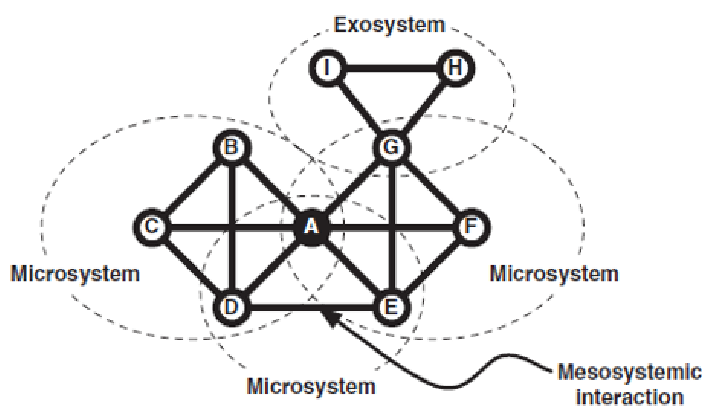

Figure 1.1. Neal and Neal's (2013) nested model of ecological systems, focused on person A (p. 729, Neal & Neal, 2013).

Networked EST, as described by Neal and Neal (2013), identifies system levels based on the general patterns of social interactions. Organizing the problem of practice into networked EST levels provides an understanding of how the various factors and themes associated with the problem of practice interact with each other and with the focal individual (i.e., AP students). These system levels include chronosystem, macrosystem, exosystem, mesosystem, and microsystem. The chronosystem frames the understanding of change over time relative to the focal individual and to the arrangement of systems surrounding the focal individual. Macrosystem level factors include large-scale social and cultural influences on smaller-level systems. Exosystem level interactions do not directly involve the focal individual, but the results of interactions at this level affect the focal individual directly or indirectly. Mesosystem level interactions occur between individuals in different settings, both of which include the focal individual. Microsystem level interactions occur between focal individual and their immediate environment (Neal & Neal, 2013).

Factors Related to Student Preparedness and Success in Advanced Placement Courses

Applying Neal and Neal's (2013) networked EST to student preparedness and success in AP courses helps frame the relationships among factors influencing the problem of practice. An important chronosystem factor related to the problem is the shift in the ethos of the AP program since its inception; from elitist to inclusive and expansive (Judson & Hobson, 2015; Rothschild, 1999). Macrosystem level factors investigated in this study include the benefits of the AP Program, specifically access to AP courses and success in AP courses. Exosystem level factors related to student preparedness and success in AP courses include federal, state, and local policies intended to increase equitable access to AP courses by increasing AP enrollment. Mesosystem level factors that influence student preparedness and success in AP courses include school characteristics that support or hinder AP access and performance, AP teacher background, and AP teacher practices. Microsystem student-level factors that influence student preparedness and success in AP courses include student motivation to enroll in AP courses, student attitudinal factors, family and peer influences, and student prior knowledge. Framing this literature review through Neal and Neal's networked EST lens, as shown in Figure 1.2, provides the structure and organization necessary to thoroughly understand the factors related to student preparedness and success in AP courses and how those factors interact with each other.

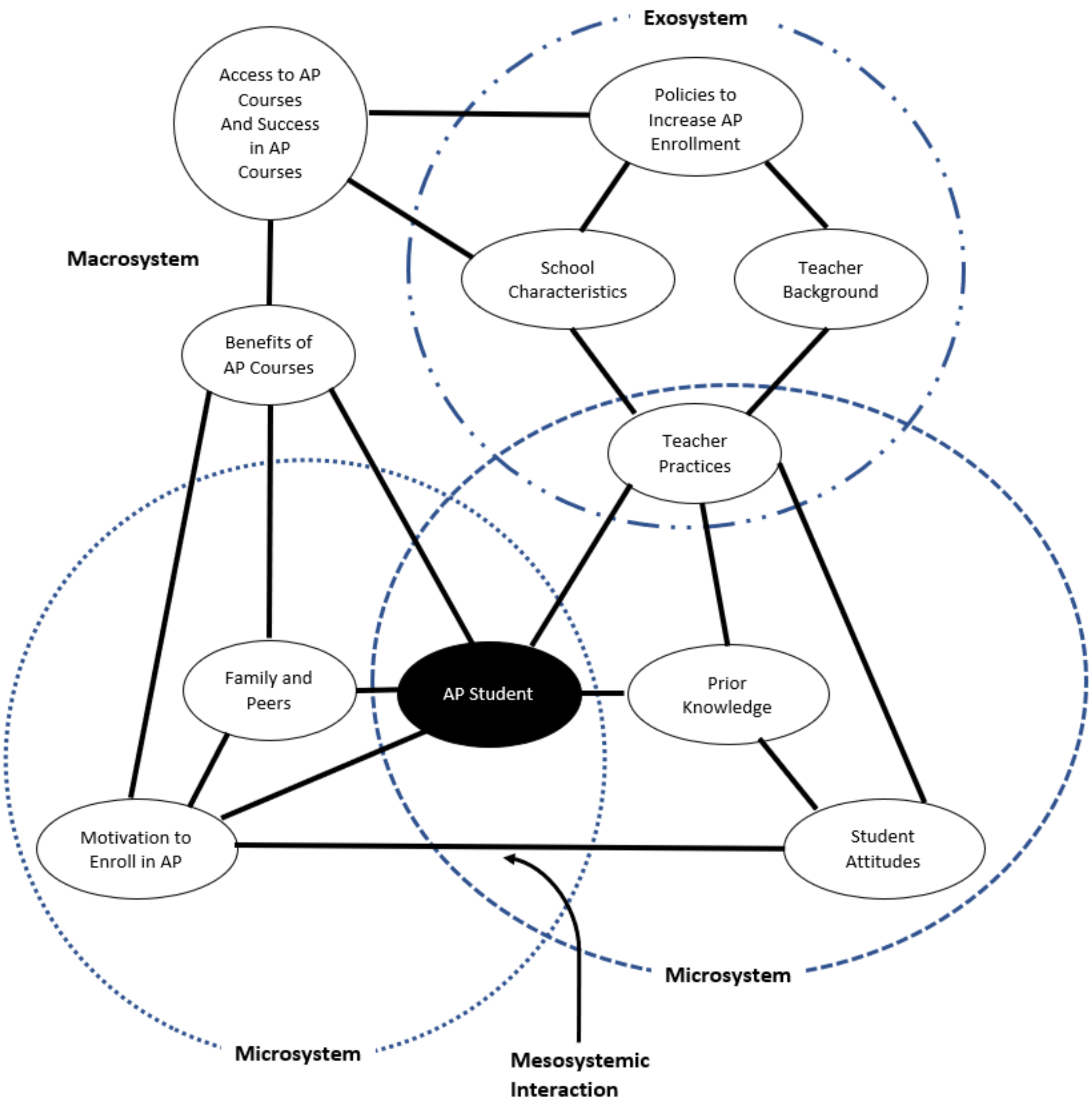

Figure 1.2. Nested EST framework of systems related to the AP student.

Applying Neal and Neal's (2013) nested EST framework to the literature related to student preparedness and success in AP courses led to the conceptual framework (Figure 1.3) for the present study, which illustrates the relationships among the factors related to this problem of practice. Although this literature review investigates important chronosystem and macrosystem factors related to student preparedness and success in AP courses, those large-scale factors are not included in the conceptual framework because of practical limitations of the scope of this study. The conceptual framework identifies exosystem district policies related to AP access and AP enrollment as influencing school characteristics and teacher factors. School characteristics that support or hinder AP preparation and success influence teacher factors and student factors. Interactions between teacher factors and student factors ultimately influence student preparedness and success in AP courses.

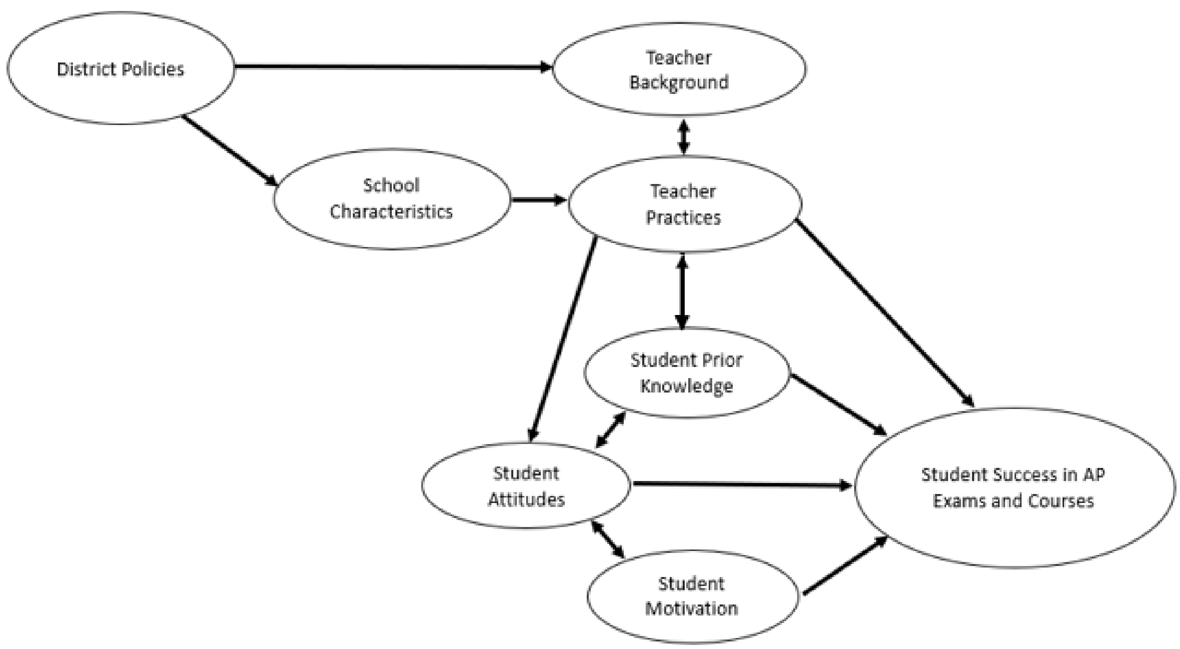

Figure 1.3. Conceptual framework of factors influencing student success in AP courses

This literature review will begin by describing a macrosystem factor – the benefits of the Advanced Placement program – which substantially influences student motivation to enroll in AP courses, a factor that will be revisited in the microsystem student-level factors section. Access to AP courses and success in AP courses are the next macrosystem factors detailed, followed by the exosystem factors, mesosystem factors, and microsystem factors that influence factors related to student preparedness and success in AP courses.

Benefits of the Advanced Placement Program

The AP program is sponsored by the College Board organization as a pathway to rigorous, college-level coursework for high school students (College Board, 2014). Policy-makers and educational leaders who advocate for the AP program claim students who enroll in AP courses have increased opportunities to experience accelerated, challenging learning which helps prepare them for their academic futures (Sadler, Sonnert, Tai, & Klopfenstein, 2010). Alternate accelerated programs, such as dual enrollment in college courses and International Baccalaureate (IB) programs, offer similar benefits as the AP program provides for students (Klopfenstein & Thomas, 2009; Sadler & Tai, 2007). Both AP and IB programs provide high school students with accelerated, rigorous curricula designed to increase college preparation for students and offer students opportunities to earn college credits through end-of-year exams (Suldo, Shaunessy-Dedrick, Ferron, & Dedrick, 2018). To contrast the AP and IB programs, although the AP program is offered globally, IB programs are more common internationally, whereas the AP program is the far more common accelerated curricular program in the United States. Further, the IB program is designed as a diploma program featuring multiyear courses, whereas the AP program is comprised of 38 courses which students may enroll in on a course-by-course basis (Suldo et al., 2018). This section will describe benefits of the AP program, including benefits related to reduced college tuition, academic advantages (e.g., future SAT scores and double majoring), college completion, and college course grades.

The benefits of AP courses are most notable for students who pass (i.e., exam scores of 3, 4, or 5 out of 5) the AP exam (McKillip & Rawls, 2013; Morgan & Klaric, 2007; Morgan, Zakhem, & Cooper, 2018; Smith et al., 2017). Students can often earn college credit for passing AP exams, and thereby reduce the time needed to obtain college degree and save money from associated tuition and fees (Evans, 2019). Students who participate in AP courses and exams have also scored higher on related college entrance exams (i.e., SAT; McKillip & Rawls, 2013). An investigation of students who took the PSAT in fall of grade 11, one or more AP exams in spring grade 11, and the SAT during grade 12 in 2009 revealed predictive relationships among the three exams (McKillip & Rawls, 2013). The study examined students who took one of three possible AP exams (i.e., calculus AB [*n* = 13,321], chemistry [*n* = 15,503], or English language [*n* = 80,911]) during grade 11. Using multi-level regression, the authors found that while students' PSAT scores predicted much of the variance in students' SAT scores (e.g., 45% for Mathematics), additional variance in SAT scores was explained by students' performance on AP exams (e.g., 13% for Mathematics). Notably, the increases in predicted scores for Mathematics ranged from 29 additional SAT points for students who earned a 2 on the AP Calculus AB exam to 66 additional SAT points for students who earned a 5 on AP Calculus AB exam. Similar findings were reported for Chemistry and English language. The authors suggested student motivation factors or school-level characteristics (e.g., teacher effectiveness) as possible reasons the students who scored lower on AP exams did not fully benefit from their AP coursework (McKillip & Rawls, 2013). Additional academic benefits available for students who pass AP exams and earn college credit include double majoring (Evans, 2019) and enrolling in more advanced academic courses more often than students who do not earn college credit from AP exams (Ackerman et al., 2013; Evans, 2019). An analysis of 72,457 students from 27 colleges determined, for most content areas, students who earned a passing AP exam score in a specific content area earned higher grades in intermediate college courses in that same content area than did non-AP students who took the corresponding introductory course in college instead of the corresponding AP course (Morgan & Klaric, 2007). Similarly, a 1999-2009 study of 26,693 college students with AP experience in high school showed completion of AP exams in high school was a predictor of positive college outcomes, such as increased college course grades and graduation rates (Ackerman et al., 2013). However, students who took AP courses but who did not receive college credit because of not earning passing AP exam scores performed similarly in college as students who did not complete any AP Exams; indicating AP exam performance—not only AP course enrollment or course completion—is a key ingredient for conferring academic benefits in college (Ackerman et al., 2013). In a study including more than 4.5 million students between 2004-2009, each AP exam a student passed corresponded with a 1-2% increased likelihood of their completing college in four years (Smith et al., 2017). In contrast to these studies that suggested passing AP exams is required to confer benefits, a relatively small study of 1,464 students in one suburban school district from 2004-2009 identified a positive relationship between AP course participation and completing college in six years (Morgan et al., 2018). Limitations to the generalizability of this study included that its data were derived from only one school district yielding a relatively small sample size, its use of a binary outcome variable for college graduation, and six years is a relatively low standard to measure graduation rate when compared to studies that measure college completion within four years, such as Smith and colleagues (2017). Overall, except for Morgan and colleagues (2018), most research relating AP coursework with future academic benefits for AP students holds true only when the students are successful on the AP exams—not simply when they participate in AP courses. Collectively, these findings about the general population of AP participants indicate positive academic benefits for students that extend beyond AP coursework.

In contrast, additional research suggested AP participation masks other, underlying variables that may also contribute to future benefits for students (Klopfenstein & Thomas, 2009;

Sadler & Tai, 2007). A study of more than 28,000 high school graduates who attended 31 Texas public universities found college success—measured by college grade point average (GPA) and second year retention rates—was higher for students who participated in AP coursework compared to students who never enrolled in an AP course (Klopfenstein & Thomas, 2009). However, that advantage for AP students disappeared when controlling for non-AP coursework taken in high school, such as honors level courses (Klopfenstein & Thomas, 2009). That finding indicates other academic experiences and non-AP coursework may have influenced the college success outcome measures as much or more so than the AP coursework; therefore, the authors questioned whether the apparent advantage former AP students had in college was due to their AP experience or due to other academic or personal factors (Klopfenstein & Thomas, 2009). Similarly, a survey of 8,594 students from 55 colleges and universities indicated students who passed at least one AP Exam in high school earned higher college course grades; however, that advantage was reduced by approximately half when controlling for demographic factors and non-AP prior academic achievement such as SAT scores and highest-level math course completed (Sadler & Tai, 2007). Furthermore, this study showed college course grades in introductory biology, chemistry, and physics were not significantly different between students who participated in AP coursework but earned low AP Exam scores (i.e., 1 or 2) and students who never participated in an AP course (Sadler & Tai, 2007).

Using ACT scores as an outcome measure of student success, a two-year state-wide study in Utah of over 90,000 students indicated students who passed either an AP English exam or an AP calculus exam corresponded with higher ACT English or ACT mathematics scores, respectively (Warne, Larsen, Anderson, & Odasso, 2015). These authors stratified the population into four ordered groups: (1) non-AP students, (2) AP exam nonparticipants, (3) AP exam nonpassers, and (4) AP exam passers. The authors then used propensity score matching and regression analysis to calculate estimated marginal mean ACT scores for each group; they then compared the estimated marginal mean ACT scores for adjacent groups. The results revealed nominal mean differences (some even negative) with small effect sizes among the non-AP students, AP exam nonparticipants, and AP exam nonpassers; and much greater, positive mean differences with large effect sizes between AP exam nonpassers and AP exam passers. For example, the effect of passing the 2011 AP English exam resulted (on average) in increases of 5.295 points on ACT Reading scores ($d = 0.91$), and the effect of passing the 2011 AP calculus exam resulted (on average) in increases of 3.206 points on ACT Math scores ($d = 0.74$; Warne et al., 2015). Collectively, these studies that indicate students must take and pass AP exams to reap the benefits of AP courses underscore the complexity of the AP program and highlight a need to better understand to what extent AP courses and other student and school variables contribute to future benefits for students.

Access to Advanced Placement Courses

Recent efforts to increase AP enrollment have primarily aimed to increase access to rigorous AP courses for traditionally underrepresented populations of students (College Board, 2014; Judson & Hobson, 2015). The historical and persistent underrepresentation of certain student groups—based on gender (Campbell, Brown, & Perry, 2009; Corra, Carter, & Carter, 2011; Moller, Stearns, Southworth, & Potochnick, 2013; Moore & Slate, 2008; Watt, Huerta, & Martinez, 2017), race (Cisneros et al., 2014; Conger, Long, & Iatarola, 2009; Corra et al., 2011; Fenty & Allio, 2017; Iatarola, Conger, & Long, 2011; Judson, 2017b; Judson & Hobson, 2015; Malkus, 2016; Moore & Slate, 2008; Ndura, Robinson, & Ochs, 2003; Soloranzo & Ornelas, 2004), socioeconomic status (SES; Klopfenstein, 2004; Moore & Slate, 2008; Zarate & Pachon, 2006), and urbanicity (Barbour & Mulcahy, 2006; de la Varre, Irwin, Jordan, Hannum, & Farmer, 2014; Fenty & Allio, 2017; Irwin, Hannum, Farmer, de la Varre, & Keane, 2009) have been reported to exist due to underlying societal inequities at the macrosystem level. This section will discuss research that describes the relative access to AP courses for student subpopulations defined by gender, race, SES, and urbanicity.

Gender. The majority of research indicated females and males have equal access to AP courses, but females enroll in AP courses more frequently than males (Campbell et al., 2009; Corra et al., 2011; Moller et al., 2013; Moore & Slate, 2008; Watt et al., 2017). Recall, AP access is defined as the opportunity for students to participate in at least one AP course at the school they attend (Gagnon & Mattingly, 2016). A statewide analysis in Texas of AP enrollment during the 2004-2005 (N = 1,789 schools) and 2005-2006 (N = 1,809 schools) school years indicated a higher percentage of females (17%) than males (13%) participated in AP courses (Moore & Slate, 2008). Similarly, a six-year statewide analysis in California (N = 874 schools) of enrollment in AP mathematics and science courses found the rate of increase in AP enrollment for females was greater than males over the study period (Campbell et al., 2009). Further evidence of female high school students taking advantage of AP offerings was described by Moller and colleagues (2013), who analyzed National Education Longitudinal Study of 1988/2000 data. Although both males and females from schools that offered relatively high numbers of AP courses were more likely to attend selective colleges—as indicated by SAT scores of each colleges' students—than students from schools that offered relatively few AP courses, females were more likely to attend selective colleges than males (Moller et al., 2013). This finding may indicate females leverage their AP coursework more effectively than males in terms of college admissions (Moller et al., 2013). Although these studies indicated females disproportionally took advantage of access to AP courses compared to males, a four-year mixed-method study including more than 200 high schools from across the United States indicated that males and females equally accessed AP courses (Watt, 2017). Conversely, in a study using 2002-2003 data of one school district (N = 5,470 students) in North Carolina, Corra and colleagues (2011) used SAT scores to predict expected AP enrollment and compared that expected enrollment to actual AP enrollment, aggregated by gender. Results from this analysis indicated that females showed lower levels of AP enrollment than expected for most AP courses based on their SAT scores as predictors for AP enrollment, with the exceptions of English and foreign language AP courses (Corra et al., 2011). The authors acknowledged because their study was limited to one school district in one academic year, their findings may not be generalizable to other contexts (Corra et al., 2011). Factors that have influenced male and female enrollment in AP courses have most recently resulted in the number of AP exams taken shown in Table 1.3 (College Board, 2018).

Table 1.3

Number of Male and Female Students Taking AP Exams in 2018 in the United States

Gender	Number of students who took at least one AP exam	Percent of students who took at least one AP exam	Total number of AP exams taken	Percent of total number of AP exams taken
Male	1,225,036	43.6	2,293,034	45.0
Female	1,583,954	56.4	2,797,290	55.0

Collectively, research regarding AP access by gender indicated females enrolled in AP courses more frequently than males and thereby took advantage of the opportunities to access rigorous coursework in high school. Research into AP access by race has produced clear and definitive results.

Race. Historically underrepresented minority students have less access to AP courses and enroll in AP courses less than White and Asian students (Corra et al., 2011; Judson, 2017b; Judson & Hobson, 2015; Malkus, 2016; Moore & Slate, 2008). The construct of AP access by race encompasses two related but distinct definitions in the literature. The first definition relies on whether students choose to enroll in AP courses and is consistent with how researchers describe access to AP courses for males and females (Cisneros et al., 2014; Conger et al., 2009; Corra et al., 2011; Judson, 2017b; Judson & Hobson, 2015; Malkus, 2016; Moore & Slate, 2008; Ndura et al., 2003). Alternatively, some researchers adopt a different definition of AP access which describes whether students of different races have access to AP courses depending on whether the high schools they attend offer AP courses (Cisneros et al., 2014; Conger et al., 2009; Fenty & Allio, 2017; Iatarola et al., 2011; Malkus, 2016; Soloranzo & Ornelas, 2004). Using the first definition of AP access, Corra and colleagues (2011) found among students with high SAT scores, White students enroll in AP courses at higher rates than Black students, based on expected AP enrollment predicted by SAT scores. Similarly, a survey of eight high schools showed minority groups, other than Asian, are greatly underrepresented in AP courses (Ndura et al., 2003). In addition, an analysis of national data sets from 2012 and 2013 demonstrated AP participation is stratified by race; 41% of White students participated in at least one AP course in high school, compared to 27% of Black students, 36% of Hispanic students, and 70% of Asian students (Malkus, 2016). Similarly, using a 2009 national data set, Judson and Hobson documented the ratio of AP Exams taken per high school graduate by race as 2.42 exams per Asian student, 0.90 exams per White student, 0.85 exams per Hispanic student, 0.41 per American Indian student, and 0.39 per Black student. Using a statewide analysis of 2004 to 2006 data in Texas, Moore and Slate (2008) found a higher percent of White (19%) students enrolled in AP courses compared to Black (10%) and Hispanic (12%) students. Wilcoxon signed rank tests revealed White students enrolled in AP courses significantly more than Black students in 2004-2005 (z = 21.195, p = 0.0001) and in 2005-2006 (z = 21.572, p = 0.0001); White students enrolled in AP courses significantly more than Hispanic students in 2004-2005 (z = 24.324, p = 0.0001) and in 2005-2006 (z = 24.494, p = 0.0001); and Hispanic students enrolled in AP courses significantly more than Black students in 2004-2005 (z = 2.686, p = 0.007) and in 2005-2006 (z = 3.531, p = 0.0001). This finding is consistent with a 2009-2010 Arizona statewide study that found, based on overall school enrollment demographics, White and Asian students enrolled in AP courses disproportionally more frequently than Black, American Indian, and Hispanic students (Cisneros et al., 2014). Research clearly indicates historically underrepresented minority students enrolled and participated in AP courses at lower rates than White and Asian students. However, national growth in enrollment in science, technology, engineering, and mathematics (STEM) AP courses and non-STEM AP courses was greatest for Black and Hispanic students from 1997 to 2013 (Judson, 2017b). Enrollment in STEM AP courses increased from 1997 to 2013 by 929% for Hispanic students, 518% for Black students, 340% for Asian students, 287% for Native American students, and 252% for White students; enrollment in non-STEM AP courses increased from 1997 to 2013 by 799% for Hispanic students, 736% for Black students, 522% for Native American students, 423% for Asian students, and 278% for White students (Judson, 2017b). Finally, using Florida statewide panel data from 2003 and 2006, White students were approximately three times more likely to enroll in AP courses than Black and Hispanic students; however, those disparities were eliminated when controlling for pre-high school characteristics (e.g., students' eighth grade test scores, limited English proficiency, and learning disabilities), indicating race may not be a critical factor in influencing AP access (Conger et al., 2009). Factors that have influenced enrollment in AP courses by race have most recently resulted in the number of AP exams taken shown in Table 1.4 (College Board, 2018). Additional research has analyzed AP access to determine if schools that serve primarily certain races equitably offer AP courses.

Table 1.4

Numbers of AP Exams Taken by Race in the United States

Race	Total number of AP exams taken in 2018*	Percent of total exams taken in 2018*	Percent of United States population in 2017**
American Indian / Alaskan Native	12,459	0.3	0.7
Asian	740,825	15.0	5.5
Black	308,791	6.3	12.3
Hispanic/Latino	1,092,606	22.2	18.1
Native Hawaiian / Other Pacific Islander	7,340	0.2	0.2
White	2,443,317	49.6	60.6
Two or more races	223,259	4.5	2.4
Other	98	0.0	0.3
No response	94,377	1.9	-

*College Board, 2018
**"American Community Survey," n.d.

Investigations into AP access by race according to the second definition of AP access – which describes whether students of different races have access to AP courses depending on if the high schools they attend offer AP courses – have produced mixed results (Cisneros et al., 2014; Fenty & Allio, 2017; Iatarola et al., 2011; Malkus, 2016; Soloranzo & Ornelas, 2004). A statewide study in Florida from 2001-2006 indicated schools with higher minority populations were more likely to offer AP courses than schools with higher White populations (Iatarola et al., 2011). Contrastingly, a 2009-2010 statewide study in Arizona found schools serving high minority populations were less likely to offer a wide range of AP courses (Cisneros et al., 2014). Similarly, a 2000-2001 analysis of 780 California schools operationalized AP access by dividing the school enrollment by the number of AP courses offered—named the AP student access indicator (APSAI)—and found that schools with relatively high Latinx enrollment had lower APSAI, suggesting Latinx students had less access to AP courses than White students and were thereby underrepresented in AP courses overall (Soloranzo & Ornelas, 2004). Two national studies reported students of different races had almost the same likelihood of attending a school that offers AP courses; White (87%), Black (88%), Hispanic (92%), and Asian (95%) identified by Malkus (2016) in 2012 and 2013, and in the 2011-2012 school year, Rodriguez and McGuire (2019) found 90% of Black students and 89% of White students attend a school that offers AP courses. Finally, Conger and colleagues (2009) used Florida statewide panel data to show relatively small differences in the percent of students by race who attended a high school that offered at least one mathematics AP or IB course in 2003; all (90%), White (89%), Black (89%), Hispanic (95%), and Asian (97%). These mixed results do not suggest that expanding access to AP courses will positively affect enrollment by race; thus, differences observed in AP enrollment by race may be due to factors other than access. Nonetheless, the relationship between AP access and SES has also been investigated.

Socioeconomic status. Economically disadvantaged students enroll in AP courses at lower rates than economically advantaged students. (Malkus, 2016; Moore & Slate, 2008; Ndura et al., 2003; Zarate & Pachon, 2006). An investigation of eight high schools in a single school district during 2002-2003 found schools that served high SES students offered more AP courses and had correspondingly higher AP enrollment than schools serving low SES students (Ndura et al., 2003). Similarly, an analysis of 1,094 public California high schools in 2003 found the proportion of students eligible for free or reduced-price lunch negatively correlated with the number of AP courses offered (Zarate & Pachon, 2006). Additionally, an investigation of 1,789 schools in 2004-2005 and 1,809 schools in 2005-2006 in Texas found student enrollment rate in AP courses was lower for economically disadvantaged students (approximately 10%) than the general student population (almost 15%; Moore & Slate, 2008). Using parent education level as an indicator of SES, in 2013, an analysis of national panel data indicated students with parents who graduated college were more likely to take AP courses (54%) than students with parents with only some college experience (34%), parents who only graduated high school (29%), and parents who did not finish high school (29%; Malkus, 2016). This relatively low AP enrollment for low-income students has prompted AP expansion programs to attempt to recruit students from high poverty backgrounds (Fenty & Allio, 2017). Contrasting these studies that indicated economically disadvantaged students have reduced access to AP courses, a 2003 and 2006 analysis of statewide panel data from Florida found students from high SES backgrounds were three times more likely to enroll in AP courses than students from low SES backgrounds; however, that poverty gap (i.e., difference in enrollment likelihood between students of high and low SES backgrounds) was reduced by 68% and 77% in the two years studied when controlling for differences between students before they enter high school (e.g., 8^{th} grade test scores and demographics), which indicated SES may not influence AP enrollment as substantially as other factors (Conger et al., 2009). Research of the relationship between urbanicity and access to AP courses also warrants investigation.

Urbanicity. Rural schools, which tend to be more remote (Gagnon & Mattingly, 2016), often provide less access to AP courses than suburban and urban schools (Cisneros et al., 2014; Gagnon & Mattingly, 2016; Klopfenstein, 2004). Researchers described relationships between urbanicity and AP access through virtual AP (VAP) programs that provided students in districts with low numbers of potential AP students the opportunity to participate in AP coursework (Barbour & Mulcahy, 2006; de la Varre et al., 2014; Fenty & Allio, 2017; Irwin et al., 2009). Virtual AP programs offer a potential solution for rural school districts to provide AP access for students who otherwise would not be able to enroll in AP courses because of limited numbers of interested students or qualified teachers in rural areas (Gagnon & Mattingly, 2016). An analysis of 2012 national data revealed only 51% of rural school districts enrolled students in in-person AP courses, compared to 78% for town districts, 94% for suburban districts, and 97% for urban districts (Gagnon & Mattingly, 2016). Similarly, in 2,000, only 44% of rural Texas high schools provided an in-person AP program compared to 73% for non-rural districts (Klopfenstein, 2004). This finding of relatively low access to AP courses in rural districts was later supported by a similar 2010 study in Arizona (Cisneros et al., 2014).

Success in Advanced Placement Courses

Substantial research has demonstrated that merely accessing AP courses does not necessarily yield academic advantages; rather, successfully passing AP exams appears critical to gain the full benefits of AP coursework (Ackerman et al., 2013; McKillip & Rawls, 2013; Morgan & Klaric, 2007). Further, research suggested that the recent rapid growth of the AP program may not have included all components necessary to ensure each and every AP student's success (Klopfenstein & Thomas, 2009; Malkus, 2016b; Sadler & Tai, 2007; Warne et al., 2015).

This section discusses research investigating if sociocultural macrosystem inequities contribute to stratified AP success based on student subgroups of gender, race, SES, and urbanicity.

Gender. Success rates of males and females in AP courses and how male and female students' AP coursework relates to future academic advantages has yielded mixed results (Ackerman et al., 2013; Malkus, 2016; Moore & Slate, 2008; Campbell et al., 2009). An analysis of a national data set from 1990-2009 showed approximately 13% of both males and females earned college credit as a result of passing AP exams in 1990; however, throughout the study period, the percent of female high school graduates who earned college credit from AP exams gradually increased more than the percent for males, resulting in 43% of female graduates earning credit compared to 35% of males in 2009 (Malkus, 2016). An analysis of more than 26,000 college students at one university between 1999-2009 found the relationship between AP exam scores and college grades in courses of the same content area was uniformly positive for both males and females (Ackerman et al., 2013). In contrast to those two studies which indicated equal or greater success for females resulting from AP participation, a two-year statewide analysis in Texas found males passed AP exams (i.e., earned a score of 3 or higher) at significantly higher rates than females for all AP exams taken in 2005 (male pass rate = 43.5%, female pass rate = 41.5%) and 2006 (male pass rate = 42.1%, female pass rate = 39.5%; Moore & Slate, 2008). Similarly, a statewide study in California investigated science and mathematics AP success from 1998 through 2003 and found males passed AP exams at significantly higher rates than females in mathematics (males = 48.6%, females = 41.0%) and science (males = 40.1%, females = 31.6%; Campbell et al., 2009). These varied reports do not indicate any consistent patterns relating gender to AP success. However, investigations into AP success based on race suggest more stratified results.

Race. Several studies investigating success in AP courses, as measured by AP Exam scores, found racial minority students, especially Black students, underperform on AP Exams compared to White and Asian students (Cisneros et al., 2014; Judson, 2017b; Judson & Hobson, 2015; McBride-Davis et al., 2015; Moore & Slate, 2008). Findings from the analysis of a national data set from 1997-2012 indicated that AP exam pass rates remained relatively stable for White (66% in 1997, 65% in 2012) and Asian (67% in 1997, 68% in 2012) students over the 16 year period, with pass rate standard deviations of 1.1% and 1.4%, respectively. However, AP exam pass rates decreased from 1997 to 2012 for students of other races. Specifically, regression analysis indicated AP exam pass rates decreased for American Indian students' from 51% in 1997 to 46% in 2012 ($R^2 = .56$, $p < .05$), Hispanic students' from 61% in 1997 to 43% in 2012 ($R^2 = .94$, $p < .001$), and Black students from 36% in 1997 to 29% in 2012 ($R^2 = .81$, $p < .001$; Judson & Hobson, 2015). Furthermore, an analysis of national data from 1997-2013 indicated an increase in the percent of STEM discipline AP students earning the lowest possible AP Exam score of 1, and the greatest increase in students earning a 1 has been for underrepresented minorities, indicating decreasing STEM AP success for minority students (Judson, 2017b). Likewise, a 2009-2010 study of more than 250,000 students in Arizona found 37% of Asian students enrolled in at least one AP course passed one or more AP exams, compared to 35% for White students, 26% for Hispanic students, 14% for Black students, and 8% for American Indian students (Cisneros et al., 2014). A statewide study in Texas measuring student pass rates on AP exams in 2005 and 2006 found slightly different findings (Moore & Slate, 2008). Hispanic students passed AP exams at higher but not significantly different rates (47% in 2005 and 44% in 2006) than White students (43% in both 2005 and 2006), and both Hispanic and White students passed AP exams at significantly higher rates than Black students (32% in 2005 and 31% in

2006; Moore & Slate, 2008). Additionally, some states have passed legislation in support of efforts to increase AP enrollment, such as subsidizing AP exam fees (i.e., Texas, New York, and Florida) and paying teachers $50 for each AP exam passed by students (i.e., Florida; McBride-Davis et al., 2015). An investigation of AP success from 1997 through 2012 in these three states found Black students experienced relatively low AP exam pass rates (Texas [27%], Florida [27%] and New York [35%]; McBride-Davis et al., 2015) compared to global AP exam pass rates which were never lower than 58% during the study period (College Board, 2018). Collectively, these studies suggest there is an AP Exam performance gap among races, with Asian and White students scoring relatively higher than Hispanic, Black, and American Indian students. Additional studies have sought to determine if a relationship exists between SES and AP success.

Socioeconomic status. Relative to the research on gender and race, little research has been conducted to analyze the relationship between SES and AP success. One mixed-methods study of 48 highly motivated, college-bound high school graduates classified as low-income based on qualifying for free and reduced meals (FARM) indicated low-income students earned relatively low scores on AP Exams (Hallett & Venegas, 2011). Additionally, interviews with those 48 low-income students during the summer before entering college revealed they endured a low-quality AP experience (Hallett & Venegas, 2011), which is a measure of AP success infrequently presented in the literature. When asked to describe their AP experience and if their AP course(s) prepared them for college, many students independently drew connections between their classroom experiences and their AP exam score (Hallett & Venegas, 2011). Factors that contributed to these students self-reported low-quality AP experience included AP teachers not being prepared or motivated, a lack of alignment of the course materials to the AP exam, and school scheduling and infrastructure issues that negatively influenced students' experience and performance in AP courses (Hallett & Venegas, 2011). Additionally, an analysis of the national Educational Longitudinal Study of 2002 indicated students' low SES is a predictor of low AP Exam scores compared to students of high SES (Jeong, 2009). Further, an analysis of 2012 national data found 52% of AP students in the top income quartile passed at least one AP Exam compared to 24% of AP students in the lowest income quartile (Gagnon & Mattingly, 2016). An investigation in California to determine the effectiveness of statewide efforts to increase AP offerings and enrollment for economically disadvantaged students between 2000 and 2002 indicated that gains in AP offerings and enrollment in poor communities were offset by similar gains in affluent communities due to actions of affluent schools and families who also advocated for improvements of their schools' AP programs (Klugman, 2013). The author claimed that the community had effectively maintained inequities (EMI). This theory is described by Lucas (2001) as "socioeconomically advanced actors secure for themselves and their children some degree of advantage wherever advantages are possible" (p. 1652). This EMI framework may be an important driver of continued inequities in AP success, which are implied by findings from two ethnographic studies of affluent high schools (one private and one public) which found families and schools used their high SES to maintain advantages by using AP courses and exams to leverage advantages in college admissions (Weis & Cipollone, 2013). Both groups of families (private and public schools) utilized their capital (social and economic) to position themselves for continued advantage, specifically in terms of competitive college admissions (Weis & Cipollone, 2013). Other studies have analyzed potential relationships between urbanicity and AP success.

Urbanicity. Investigations of correlations between urbanicity and AP success have primarily addressed relative success of virtual AP programs (VAP) designed to improve AP access to students in rural districts (Barbour, 2008; Barbour & Malcahy, 2006; Johnston & Barbour, 2013). However, one large study that analyzed 2012 national data from 6,765 school districts reported relatively low AP success for students attending rural and town schools – the percent of AP students who passed at least one AP exam was 45% in suburban schools, but only 36% in urban schools, 32% in town schools, and 32% in rural schools (Gagnon & Mattingly, 2016). Regarding the success of VAP programs, a 2009-2011 study of Florida virtual AP students (N = 2,326) found VAP students performed equally or better than classroom-based AP students in Florida (N = 171,724) and nationally (N = 1,082,144; Johnston & Barbour, 2013). Similarly, of the 66 Canadian schools analyzed in 2002-2003, students in VAP programs in rural schools earned higher AP Exam scores than rural students who were enrolled in classroom-based AP course (Barbour & Malcahy, 2006). Likewise, an investigation of AP Exam scores of all students in the Canadian province of Newfoundland and Labrador between 2002-2005 found students performed equally or better in VAP courses than in classroom-based AP courses, in terms of final course grades (Barbour & Malcahy, 2008). Although the literature suggested students in rural districts may not perform as well on AP Exams as students in urban and suburban districts, VAP programs have been employed to increase access and success for students interested in AP coursework in rural areas.

Policies to Increase Advanced Placement Enrollment

Educational priorities rooted in various levels of educational organizations – federal (U.S. Department of Education, 2009; Klopfenstein, 2004), state (Arce-Trigatti, 2018; Klopfenstein, 2004; Klugman, 2013; Kramer, 2016), and local (Conger et al., 2009; Klopfenstein, 2004) – have informed policies affecting AP programs and students. This section will discuss education policies aimed at increasing AP enrollment—often intended to address inequities in access to AP courses—and related factors which act at the exosystem level to AP students.

The AP Program experienced remarkable growth in the 1990s, primarily because of government funding and increased student demand (Klopfenstein, 2004). The growth of the AP Program persisted since then, and in 2009 the United States Department of Education urged schools to use stimulus funding from the American Recovery and Reinvestment Act of 2009 to expand AP programs and help prepare students for rigorous courses (U.S. Department of Education, 2009). Although school districts often determine requirements and policies for AP offerings, several states (i.e., Arkansas, Indiana, Mississippi, South Carolina, and West Virginia) have mandated all public schools offer at least an established minimum number of AP courses (Arce-Trigatti, 2018), and additional states have established other requirements aimed at expanding AP programs (Klugman, 2013). State and local mandates that establish minimums for AP course offerings and AP enrollment directly affect student outcomes through mechanisms such as changing which curricular options are available for students (Arce-Trigatti, 2018). Further, such mandates indirectly affect student outcomes through changes in what school resources are available, causing students to change schools, or changing student peer group composition (Arce-Trigatti, 2018).

Several studies have investigated the effects of state policies intended to increase AP course offerings and AP enrollment as interventions to bridge existing inequities (Conger et al., 2009; Klopfenstein, 2004; Klugman, 2013). A 1999 lawsuit, *Daniel v. State of California* – in which parents of a nearly all-minority school sued the state of California because their high school offered only two or three AP courses but nearby schools serving high-income families offered 14 to 18—prompted California to require schools increase their AP course offerings in schools that provided small numbers of AP subjects (Klugman, 2013). The state allocated resources for this intervention but funding restraints ended the intervention programs after three years, thereby limiting the AP expansion efforts (Klugman, 2013). A mixed-method study of 1,290 California schools examining efforts by the state to expand AP offerings from 2000-2002 analyzed enrollment and demographic quantitative data and interviews with district superintendents and school board members from districts serving predominantly upper-middle class families (n = 6), some upper-middle class families (n = 3), and relatively few upper-middle class families (n = 2) in 2006 (Klugman, 2013). California's attempt to promote AP access was impeded by factors that preserved class and racial inequalities because although AP access increased for low-income students, AP access increased at even higher rates at schools serving primarily high-income families (Klugman, 2013). A similar situation in Texas, where well-intended policies effectively maintained inequality, was documented in an investigation of AP course offering patterns from 1994 to 2000 following state financial incentives supporting AP program expansions in the 1990s (Klopfenstein, 2004). Although schools serving predominantly low-income and minority families greatly increased their AP course offerings in that six-year period, schools serving more affluent and White families increased their AP course offerings relatively more (Klopfenstein, 2004). Similarly, a statewide analysis of approximately 100,000 Florida high school graduates in 2003 and 2006 investigated whether demographic gaps in AP course taking had changed over those three years due to state financial incentives (Conger et al., 2009). School reforms aimed at increasing AP enrollment were successful because AP and IB enrollment increased for the 2006 graduates; however, AP enrollment increased disproportionately more for already-advantaged groups (i.e., Asian, White, female, high SES;

Conger et al., 2009). Collectively, research indicates well-intentioned policies designed to increase AP access and enrollment for traditionally underrepresented students have been successful, however, possibly due to EMI, "expanded access may simply provide a smoke screen covering inequities that persist" (Hallett & Venegas, 2011, p. 485). A description of the AP growth trends since the early 1990s will provide perspective of the magnitude of recent changes in the AP program.

The growth of student participation in the AP program over recent decades is a well-documented chronosystem factor for AP students (Arce-Trigatti, 2018; Barnard-Brak, McGaha-Garnett, & Burley, 2011; College Board, 2014; Conger et al., 2009; Judson & Hobson, 2015). An investigation of national data sets from 1996-2012 sought to describe trends in AP enrollment over the study period (Judson & Hobson, 2015). The number of high school graduates increased by 28% during the 17-year period; however, that growth was greatly outpaced by the rate of students enrolled in AP courses (291%) and AP exams taken (339%; Judson & Hobson, 2015). The increase in rate of AP exams taken is greater than the increase in rate of students enrolled in AP courses because, over the study period, more students elected to take the end-of-course AP exams (Judson & Hobson, 2015). That study also sought to determine the relationship between AP enrollment growth and AP success, as measured by AP exam scores. From 1992 to 2012, while AP enrollment rapidly increased, regression analysis indicated performance on AP exams decreased significantly, evidenced by a 1992 AP exam pass rate of 66% and a 2012 pass rate of 59% ($R^2 = 0.84$, $p < 0.001$; Judson & Hobson, 2015). Notably, the percent of students earning the highest possible AP exam score of 5 remained constant over the study period ($R^2 = 0.064$, $p = .27$); however, significant decreases in AP exam scores of 4 ($R^2 = 0.211$, p = 0.04), 3 ($R^2 = 0.963$, $p < 0.001$), and 2 ($R^2 = 0.699$, $p < 0.001$) were reported, corresponding with a significant increase in the lowest possible exam score of 1 ($R^2 = 0.897$, $p < 0.001$; Judson & Hobson, 2015). Similar trends of increasing AP enrollment corresponding with decreasing AP Exam success have been documented in additional studies (e.g., Hallett & Venegas, 2011; Judson, 2017b). However, compared to investigations of AP access and enrollment trends, studies of factors influencing AP exam score trends are difficult to locate in the literature. Trends of increasing enrollment and decreasing achievement, which indicate policies that incentivize increasing AP enrollment, should be evaluated because enrollment itself has been shown to be insufficient for rendering AP success; after all, "the mere existence of AP programs cannot be assumed to equate to excellence" (Judson & Hobson, 2015, p. 75).

Characteristics of Schools and Advanced Placement Teachers

Characteristics of schools and AP teachers interact at mesosystem levels to influence AP students' success. This section will first discuss school characteristics that may support or hinder AP access and AP success for students (Barnard-Brak et al., 2011; Burney, 2010; Flores & Gomez, 2011; Gagnon & Mattingly, 2016; Iatarola, 2016; Iatarola et al., 2011; Rowland & Shircliffe, 2016). Then, this section will present research that investigates characteristics of AP teachers' background (Fenty & Allio, 2017; Fischer et al., 2018a; Flores & Gomez, 2011; Frumin et al., 2018; Gagnon & Mattingly, 2016; Johnston & Barbour, 2013; Laitusis & Barry, 2012) and instructional practices (Coffey & Farinde-Wu, 2016; Fischer et al., 2018a; Flores & Gomez, 2011; Foust et al., 2009; Howard & Terry, 2016; Judson, 2017a; Parker et al., 2013; Rowland & Shircliffe, 2016; Schultz, Duffield, Rasmussen, & Wageman, 2014; Vela et al., 2018), and how those factors influence teachers' capacity for effective AP instruction.

School characteristics that support or hinder AP access and AP success. Various mesosystem factors may influence AP students' access to AP courses, which is often measured by the number of AP courses offered, such as school size (Barnard-Brak et al., 2011; Gagnon & Mattingly, 2016; Iatarola, 2016), school demographics (Barnard-Brak et al., 2011), teacher education, teacher experience, and student prior academic performance (Iatarola et al., 2011). Smaller schools often offer fewer AP courses compared to larger schools (Barnard-Brak et al., 2011; Iatarola, 2016; Iatarola et al, 2011). An analysis of more than 111,000 school districts using 2012 national data sets determined that relatively few AP offerings in small schools may be due to small schools having relatively low numbers of capable students compared to large schools (Gagnon & Mattingly, 2016). Further, a study using Florida panel data of 407 school districts in 2001-2002 and 2005-2006 found approximately 3% of the smallest schools (i.e., the 10% of schools with the lowest student enrollment) offered either AP or IB courses, compared to 100% of the largest schools (i.e., the 30% of schools with the highest student enrollment; Iatarola et al., 2014). An investigation of 12,144 students using National Education Longitudinal Study of 1988/2000 data found, when controlling for school size, as the percent of minority and low SES students in schools increased, the number of AP courses offered in schools slightly decreased (Barnard-Brak et al., 2011). However, percent minority and low SES characteristics of the schools were not associated with the number of students enrolled in AP courses when controlling for school size; therefore, the authors suggested disproportionate AP access existed based on the racial composition and SES composition of schools (Barnard-Brak et al., 2011). Furthermore, during a period of AP expansion due to incentives for schools, teachers, and students, Iatarola and colleagues (2011) compared data from 407 public Florida high schools in the 2001-2002 school year to the 2005-2006 school year to determine what school or student characteristics correspond to AP course offerings. Teacher education and experience did not correlate to the number of AP course offerings; rather, the most important factor associated with more AP course offerings at a school was the number of students entering that high school with far above average 8th grade state assessment scores (Iatarola et al., 2011). This association implies while increasing AP course offerings, additional factors also need to be considered, such as effectively building a population of well-prepared students (Iatarola et al., 2011).

Qualitative research offers possible explanations for school-level characteristics associated with low AP access for some student subpopulations (Rowland & Shircliffe, 2016; Flores & Gomez, 2011). A qualitative investigation of three suburban Florida schools during the 2009-2010 school year included interviews with 30 district leaders, principals, and teachers (Rowland & Shircliffe, 2016). This study followed a period of rapid school population growth and demographic changes since 2000 and sought to determine what barriers existed for increasing AP course enrollment for traditionally underserved students (Rowland & Shircliffe, 2016). All participants shared support for ongoing efforts to open access to AP courses for students in the "academic middle" (Rowland & Shircliffe, 2016, p. 413); however, the perceived barriers to achieving that goal differed by participant group. District and school administrators identified teacher gatekeeping (i.e., careful selection of students entering their AP course) and parent resistance to expanding AP enrollment as the major barriers to effectively increasing AP enrollment for traditionally underserved students (Rowland & Shircliffe, 2016). Contrastingly, teachers claimed teacher accountability measures created disincentives to include students from the academic middle in AP courses (Rowland & Shircliffe, 2016). Teachers were afraid that if relatively more of their students received lower AP exam scores, then the teachers' perceived effectiveness would be downgraded (Rowland & Shircliffe, 2016). An investigation in an urban California school, Fontana High School, serving more than 4000 students, most of whom were described as disadvantaged Latinos, investigated student perceptions of a push to increase AP enrollment from 2008-2010 (Flores & Gomez, 2011). Student interviews indicated they supported their school actively recruiting students from non-advanced academic tracks to enroll in AP courses, but not simply to boost AP enrollment numbers (Flores & Gomez, 2011). In a meeting with the principal, these students advocated for quality instruction from qualified AP teachers; and as this school expanded its AP program, it worked to shift the mindset of all stakeholders to a stance insisting that AP courses were not only for elite students (Flores & Gomez, 2011). Various infrastructure supports were important during this AP expansion, including aligning pre-AP curricula and increasing rigor, training teachers to instruct AP courses, designing a master schedule to support smaller class sizes, building outreach programs for families and middle school students, and developing professional learning communities (PLCs; Flores & Gomez, 2011).

Research of school characteristics related to AP success is relatively limited (Burney, 2010; Flores & Gomez, 2011), unlike the amount research on school characteristics related to AP access previously described. An investigation of 339 public high schools in one midwestern state during the 2005-2006 school year used hierarchical linear regression to analyze 14 school-level variables to determine which variables correlated with AP exam performance, as measured by the ratio of passing (i.e., 3, 4, or 5) AP exam scores to total AP exams taken (Burney, 2010). Most of the variance in AP exam performance was explained by relatively fixed variables (63%, $p = .000$), such as senior class size, PSAT scores, SAT scores, and community demographics (Burney, 2010). Whereas 17% ($p = .000$) of the variance in AP Exam performance was explained by factors that schools have more control over, such as the number of AP courses offered and the number of students positioning themselves for selective college admissions by taking SAT subject tests (Burney, 2010). Small but significant variance (0.5%, $p = .016$) was explained by district-level variables including percentage of district-identified high ability students and the number of academic extracurricular activities and elementary level academic competitions (Burney, 2010). These results suggest schools should not consider school-level fixed factors as insurmountable barriers; instead, schools should focus on effective ways to provide supportive infrastructure for students and teachers that will help prepare students for academic success (Burney, 2010). Similar suggestions were made by Flores and Gomez (2011) in their previously described study of Fontana High School, who advocated that schools must provide the instructional infrastructure needed for those students moving up to AP courses to be successful. Corresponding with the AP expansion efforts that began in 2008 at Fontana High School, shown in Table 1.5, the school's state-specific academic performance index (API) rankings increased annually, as well as the school's high school exit exam pass rates, indicating additional academic benefits of AP participation (Flores & Gomez, 2011).

Table 1.5

Measures of Student Outcomes at Fontana High School Corresponding with AP Expansion That Began in 2008

Academic year	Total number of AP exams taken	Percent of AP exams earning a passing score	School's API	California high school exit exam pass rate (Math/ELA)
2006-2007	510	46	626	68/67
2007-2008	436	48	653	72/73
2008-2009	529	41	676	76/74
2009-2010	762	31	688	75/75

Contrasting these positive measures of student performance, the percent of students passing AP exams generally decreased over the same time (Flores & Gomez, 2011). These decreasing AP exam pass rates that corresponded with the school's AP expansion that began in 2008 indicate a challenge associated with expanding AP programs without first establishing required supports for AP teachers and students (Flores & Gomez, 2011). The authors propose various suggestions for schools based on their qualitative research: (a) creating school master schedules that support smaller classes; (b) making schools, parents, and students aware AP is not just for top students; (c) increasing opportunities for vertical teaming (i.e., collaboration among teachers of various grade levels in the same discipline); (d) increasing training of AP teachers on scaffolding techniques; (e) increasing rigor in pre-AP courses; (f) increasing opportunities for inter-school sharing of best practices; (g) developing a motivated AP PLC; and (h) structuring teaching assignments so AP teachers also teach lower level classes (Flores & Gomez, 2011). Some of these mesosystem level suggestions by Burney and Flores and Gomez are related to the background and training AP teachers have experienced and AP teachers' instructional practices.

Advanced Placement teacher background. The professional background of AP teachers is an important mesosystem factor that influences AP teachers' capacity to successfully implement AP curricula. Providing quality training and professional development (PD) for AP teachers may be a critical component of effectively preparing the AP student population that has become increasingly academically diverse in terms of the skills, strategies, and knowledge needed to be successful in rigorous AP courses. Researchers have studied online and in-person teacher training and PD intended to build teacher capacity for teaching AP courses. Gagnon and Mattingly (2016) identified several pathways for improving AP teachers' capacity to successfully implement AP curricula. Among the authors' suggestions is that districts provide the necessary funding for AP-specific training programs, such as AP summer institutes (APSI), which have been shown to prepare AP teachers to implement AP curricula with fidelity (Laitusis & Barry, 2012). These APSI are one-week intensive training programs led by experienced AP teachers in which participants not only collaborate about the syllabus and instruction, but they gain insights regarding AP exam scoring which can inform their classroom activities, assignments, and evaluation of student work throughout AP courses (College Board, 2018). Another online mechanism that can help prepare teachers for delivering AP curricula is the College Board's AP Teacher Community (APTC; Frumin et al., 2018). Evaluation of various formats of AP teacher development opportunities indicated the APTC—a robust, online platform designed to maximize AP teacher collaboration—offered several advantages for AP teachers (Frumin et al., 2018). Noteworthy advantages of the APTC were that it offered teachers support year-round, was intuitive for teachers because it was co-created by teachers, was helpful for AP teachers of all experience levels, reduced isolation, and provided emotional and practical support for teachers (Frumin et al., 2018). These features of the APTC allowed for convenient collaboration among AP teachers and an ability to personalize content, as AP teachers could discuss strategies and share resources (Frumin et al., 2018). These benefits of the APTC likely contributed to its association with improvements in student AP exam scores and self-reported shifts in teacher practices toward more content depth and scientific inquiry in AP biology, chemistry, and physics courses (Frumin et al., 2018). In addition to collaborating in the national APTC, opportunities for teachers to collaborate can also exist locally.

A lack of school-based, teacher-supportive environments may inhibit AP teachers' ability to collaborate with other teachers, thereby hindering teachers' capacity to effectively implement AP curricula (Fischer et al., 2018a; Fischer et al., 2018b; Flores & Gomez, 2011). Flores & Gomez (2011) investigated PD opportunities for AP teachers that may correspond with improved student outcomes. They found that developing an AP professional learning community (APPLC) across subject areas within a school was an effective mechanism to improve student success in

AP courses. The APPLC offered opportunities for frequent sharing of best practices and allowed for a congruent school-wide focus on writing skills important for AP Exams (Flores & Gomez, 2011). Providing motivated AP teachers with training in scaffolding techniques that help students advance to the next stage of learning may also support teachers' capacity to address the shifting academic profile of AP students resulting from recent efforts to increase AP enrollment (Flores & Gomez, 2011). Investigations into critical components of PD for teachers adjusting to the substantial AP Chemistry curricular and exam redesign of 2014 found AP teachers needed time, support, and training opportunities to fully implement the new curriculum (Fischer et al., 2018a). A lack of formal PD opportunities may curtail teachers' ability to effectively deliver AP instruction and implement critical components of newly designed curricula (Fischer et al., 2018b). Additionally, simply gaining experience teaching a new curriculum for multiple years provides teachers time to reflect and improve; therefore, school administration should remain supportive and patient with both novice and experienced AP teachers, particularly following a curricular overhaul (Fischer et al., 2018a).

Advanced Placement teacher practices. Advanced Placement teachers' instructional practices and attitudes impact student learning, development, and success in AP courses (Fischer et al., 2018a; Flores & Gomez, 2011; Rowland & Shircliffe, 2016). These mesosystem factors may be particularly influential for underrepresented students in the "academic middle" (Rowland & Shircliffe, 2016, p. 413) who are enrolling in their first AP courses. AP teachers who do not employ student-centered, innovative instructional designs in their courses may be limiting their students' opportunities for success (Fischer et al., 2018a). For example, cross-curricular planning and implementing interdisciplinary lessons with teachers of different content areas is a well-established practice that is beneficial for student learning (Barton & Smith, 2000; Beane, 1997;

Jacobs, 1989; Repko, 2008; Savage, 2011; Vars, 1991). Flores and Gomez (2011) found that AP teachers who do not apply this cross-curricular strategy to AP courses may not be optimizing their teaching practices. For example, the collaboration between an AP world history teacher and an Honors English teacher—who shared many of the same students—increased students' performance in both classes (Flores & Gomez, 2011). In addition, in response to the aforementioned AP chemistry curricular redesign of 2014, a study analyzing national data panels identified particularly important teaching practices: incorporating inquiry-based laboratory investigations in their classes, providing writing guidance for AP exam free-response questions, and affording opportunities for students to practice content exam questions during class; noting that teachers who did not employ these teaching practices may not have offered their students optimal opportunities for success (Fischer et al., 2018a). Furthermore, Schultz and colleagues (2014) compared student perceptions and AP exam scores of students who completed a traditional AP chemistry course to students who completed an AP chemistry course taught the following year by the same teacher, but the later course employed a flipped classroom model of instruction. The students who experienced the flipped classroom model averaged higher AP chemistry course exam scores and reported a more favorable perception of the flipped classroom experience relative to reports from the previous year's traditional classroom students (Schultz et al., 2014). Additionally, AP United States government and politics students' AP exam scores from one high school who were taught using project-based learning (PBL) instructional designs (n = 89, $\bar{x}$ = 2.33) were compared to students' AP exams scores from two similarly achieving high schools that used traditional instructional methods (n = 87, $\bar{x}$ = 2.03; Parker et al., 2013). The AP exam scores for students taught by PBL instructional designs were higher than the AP exam scores for students taught by traditional instructional methods (t[7] = 3.12, p = .018; Parker et al., 2013). By relying on cyclical teaching using projects instead of traditional teaching methods such as direct instruction, students may better learn the disciplinary ideas and skills needed (e.g., collaboration, evidence collection, claim evaluating, and contextualizing) to make evidence-based arguments related to the content (Parker et al., 2018). Cycling or spiraling previously presented ideas as newer ideas are introduced may benefit student learning by increasing long-term retention of content (Brown, Roediger, & McDaniel, 2014). The cited studies show that AP success can increase when teachers deliberately employ innovative instructional practices and curricular designs.

Developing mutual respect and an ability to productively engage with all diverse students is critical for successful learning in classes (Howard & Terry, 2016). Many AP students who have recently moved up to advanced academic coursework are students of color and represent diverse cultural backgrounds (Hallett & Venegas, 2011; Iatarola, Conger, & Long, 2011; Judson & Hobson; 2015 Klugman, 2013). Therefore, AP teachers should employ culturally responsive teaching (CRT) to optimize their positive influence on all diverse learners (Howard & Terry, 2016). A school-wide intervention study from 2004-2007 infused CRT with instructional practices through tutors, similar to teachers' aides, who worked with teachers and students during and after school (Howard & Terry, 2016). The authors showed that AP enrollment, college-going rate, and graduation rate increased for African American students when provided with effective CRT. Similarly, Coffey and Farinde-Wu (2016) demonstrated that novice AP teachers, even when of the same minority race as most of their students, understand that their own identity and background could be quite different than that of their students. Therefore, AP teachers should acknowledge and address the cultural dissonance that may exist between teachers and students by incorporating more culturally responsive instructional methods (Coffey & Farinde-Wu, 2016).

In addition to culturally responsive teaching, AP teachers may positively influence student motivation (Foust et al., 2009) and self-efficacy—which Bandura (1977) defined as an individual's belief in their ability to perform behaviors required to produce a specific desired outcome—(Vela et al., 2018) by demonstrating other positive forms of interactions with students. For instance, Foust and colleagues (2009) showed students believed their AP teachers were more enjoyable, liked their students more, and demonstrated more mutual respect than did their non-AP teachers. Teachers exhibiting affability and respect is among the strategies that teachers can use to promote positive classroom interactions and enhance student motivation to learn (Foust et al., 2009). When AP teachers also teach non-AP classes, the ways those teachers approach the different level classes has been shown to be different in terms of attitudes and instructional design (Judson, 2017a). For instance, teachers believed their AP students could handle more autonomy, needed less explanation and review of content, and benefited from more homework compared to their non-AP students (Judson, 2017a). Furthermore, in an investigation of Latinx students' perceptions of teacher support, AP students perceived more support from their teachers than non-AP students perceived from their teachers (Vela et al., 2018). Specifically, AP teachers were viewed by their students as being more accessible, investing more in their students, and expecting more of their students, when compared to non-AP teachers (Vela et al., 2018). The increased expectations and investment of AP teachers strongly correlated with students' college self-efficacy, and the increased accessibility to teachers was a strong predictor of students' vocational self-efficacy (Vela et al., 2018). Collectively, research indicates AP teacher characteristics, particularly their professional background and their instructional practices, influence students' preparedness for AP coursework and success in AP courses.

Advanced Placement Student-level Factors

This section will discuss microsystem level factors that influence students' participation and success in AP courses, namely: student motivation to enroll in AP courses (Flowers, 2008; Klopfenstein & Thomas, 2009; Sadler & Tai, 2007; Warne et al., 2015; Smith et al., 2017), student attitudinal factors (Bryan et al., 2011; Fenty & Allio, 2017; Foust et al., 2009; Ryu, 2015; Shaunessy-Dedrick et al., 2015; Vela et al., 2018), family and peer influences (Flores & Gomez, 2011; Foust et al., 2009; Shaunessy-Dedrick et al., 2015; Walker & Pearsall, 2012; Weis & Cipollone, 2013), and student prior knowledge (Hallett & Venegas, 2011; Judson & Hobson, 2015; National Research Council, 2002; Terry, de La Harpe, & Kontur, 2016; Walker & Pearsall, 2012).

Student motivation to enroll in Advanced Placement courses. Students who understand the potential benefits of the AP program may be motivated to enroll and be successful in AP courses (Warne et al., 2015). This section will first present factors related to student motivation to enroll in AP courses, followed by factors related to student motivation to be successful in AP courses.

First, reports that cite correlations between AP participation and future academic advantages may motivate students to enroll in AP courses. An analysis of approximately 25,000 students from the National Education Longitudinal Study of 1988/2000 investigated AP participation's influence on education and labor outcomes (Flowers, 2008). Compared to students who did not participate in an AP course in high school, students who participated in AP courses scored higher on college entrance exams, maintained higher undergraduate GPAs, completed higher levels of postsecondary education, and earned higher average incomes (Flowers, 2008). Flowers noted this study may have been limited because it used only descriptive statistics, and other potentially relevant variables were not analyzed (e.g., demographics, family, institution, non-AP academic factors, student attitudes, student academic background). Another study of more than 28,000 high school graduates who attended Texas public universities in 1999 controlled for more variables and reported contrasting findings (Klopfenstein & Thomas, 2009). First semester college GPAs and second year retention rates were higher for former AP students than students who never participated in an AP course; however, when controlling for non-AP coursework in high school by using multivariate regression analysis (i.e., years of science taken, years of foreign language taken, highest mathematics level completed, and participation in honors courses), there were no differences between the GPAs and retention rates for former AP students and students who never participated in AP courses (Klopfenstein & Thomas, 2009). This study's findings implied that students whose non-AP high school coursework was similar performed similarly in college, calling into question whether AP courses impacted students' college success or other student characteristics influence their college success (Klopfenstein & Thomas, 2009).

Second, expectations that AP success may confer future academic advantages may serve to motivate students to enroll in AP courses (Sadler & Tai, 2008). Sadler and Tai (2007) analyzed survey data from undergraduate students ($N = 937$) attending 55 colleges around the United States. The students were enrolled in an introductory college science and had previously completed an AP course in the same content area. Correlation analyses showed that AP exam scores correlated more to college science grades ($r = 0.328$) than other academic measures, including last high school grades in mathematics ($r = 0.216$) and English ($r = 0.189$; Sadler &

Tai, 2007). However, similar to Klopfenstein and Thomas (2009), when Sadler and Tai (2007) controlled for demographics and prior achievement, the apparent advantage for students who had previously completed the AP science course was reduced by approximately half; notably, only students who earned AP exam scores of 3 or higher earned significantly higher grades than average ($\bar{x}$ = 80.42, *SE* = 0.12) in the corresponding college introductory science course; AP exam score of 1 ($\bar{x}$ =78.25, *SE* = 1.25), 2 ($\bar{x}$ = 80.70, *SE* = 0.86), 3 ($\bar{x}$ = 81.88, *SE* = 0.76), 4 ($\bar{x}$ = 83.84, *SE* = 0.94), and 5 ($\bar{x}$ = 85.02, *SE* = 1.18). These findings indicated students need to be successful on AP exams—not merely enroll in the course—to confer academic advantages, such as earning college credit and higher grades in college (Sadler & Tai, 2007). The positive effect of achieving AP success by earning a 3 or higher on the AP exam was also supported in an investigation of two cohorts of all public high school graduates from Utah in 2010 and 2011 that indicated participation in AP English and AP calculus had no benefit for students who merely enrolled in the course, in terms of college entrance ACT exams (Warne et al., 2015). Students who took the corresponding AP exam earned slightly higher ACT exam scores, but the greatest increase in ACT scores corresponded with scores of 3 or higher on the AP exam (Warne et al., 2015). Additional support for the impact of earning a passing AP Exam score came from an analysis of a national data set of more than 4.5 million students between 2004 and 2009 (Smith et al., 2017). Earning AP Exam scores of 3 or higher increased the likelihood students would complete college in 4 years by 1-2% per exam (Smith et al., 2017). Collectively, research indicates success on AP Exams corresponds with future academic advantages, which may be a motivating factor for students to enroll and energetically participate in AP courses.

Student attitudinal factors toward enrollment and success in AP courses. Certain attitudinal constructs, such as student self-efficacy (Bryan et al., 2011; Vela et al., 2018), achievement motivation (Bryan et al., 2011; Shaunessy-Dedrick et al., 2015), and self-determination (Bryan et al., 2011), may interact with students' enrollment and success in AP or other advanced academic courses. This section will first discuss studies that analyzed microsystem attitudinal constructs through a social cognitive theoretical lens, and then present additional studies that suggest attitudinal constructs as influential factors for students' preparedness and success in AP courses.

Social cognitive theoretical frameworks have been used to investigate AP student attitude constructs (Bryan et al., 2011; Vela et al., 2018). An analysis of survey data from college students who had completed AP coursework (*n* = 57) and students who had no AP experience (*n* = 63) from the Central Southern region of the United States was conducted by Vela and colleagues (2018) based on the social-cognitive career theory (SCCT; Lent, Brown, & Hackett, 1994, 2000). The premise of SCCT is that an individual's environment and local support influence that individual's goals and career-related self-efficacy (Vela et al., 2018). Vela and colleagues (2018) found when teachers held high expectations for students and demonstrated investment (i.e., teachers engaging in behaviors to help students' future success), students benefited from increased college self-efficacy. Further, higher perceived accessibility of teachers was a strong predictor of vocational self-efficacy (Vela et al., 2018). Students enrolled in AP courses perceived their teachers as holding higher expectations and being more invested and accessible compared to students not enrolled in AP courses (Vela et al., 2018). Similarly, Bryan and colleagues (2011) used a social cognitive lens to conduct a mixed-methods analysis of first and second-year high school students enrolled in introductory science classes in a suburban public high school in the Southeast United States. This study analyzed survey data about student motivation to learn science (*N* = 228) and student interviews (*n* = 28) to understand the relationship between students' intrinsic motivation, self-efficacy, self-determination, and achievement. Students who aspired to enroll in AP courses later in high school scored higher than non-AP aspirants in intrinsic motivation, self-efficacy, and self-determination (Bryan et al., 2011). Advanced Placement aspirants were also more motivated to learn science and had higher achievement in their overall high school science course grade than non-AP aspirants (Bryan et al., 2011). Advanced Placement aspiring students stated they welcomed intellectual challenges and sought an advantage for admission at a good college, thereby demonstrating competitive attitudes toward college admission exists early in high school (Bryan et al., 2011). Student achievement motivation is fundamental in advancing students' opportunity to learn and be academically successful, and students in this study demonstrated attitudes important for AP success (Bryan et al., 2011). However, perhaps not all students enrolling in AP courses under the AP expansion policies possess these characteristics and attitudes, echoing "concerns that students are being encouraged to participate in the AP program without adequate preparation" (Bryan et al., 2011, p. 1061).

Additional microsystem factors may interfere with students developing or maintaining attitudes that support success on AP exams or in AP coursework (Fenty & Allio, 2017; Foust et al., 2009; Ryu, 2015; Shaunessy-Dedrick et al., 2015). Ryu conducted an ethnographic study of one AP biology teacher's two AP classes at a mid-Atlantic suburban school during the 2010-2011 school year, which included students who were racially, ethnically, and linguistically diverse (approximately one-third White, one-third Korean, and one-third non-Korean Asian, with a few Black and Latinx students). This investigation applied a figured worlds theoretical framework, described by Holland, Skinner, Lachicotte, & Cain (1998) as "a socially or culturally constructed realm of interpretation in which particular characters or actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p. 52). Ryu (2015) used this framework to evaluate how students were ranked or positioned differently based on their acts and behaviors that were differentially interpreted and valued in an AP biology class (Ryu, 2015). Transnational, newcomer Korean students were positioned at lower status by the teacher and students because of relatively low biology achievement and a low rate of participation in class discourse (Ryu, 2015). Language barriers contributed to newcomer Korean students' inability to adapt to United States school practices (Ryu, 2015). This study raised the question of whether AP teachers may unintentionally position students inappropriately because of expectations that are not equitable for all students, leading to a reduction of those students' self-efficacy in learning science and self-advocacy. As described previously, Fenty & Allio (2017) conducted a 2013-2015 mixed-method study of New York's virtual AP (VAP) program. Students recruited into the state's VAP program lacked time management and were not self-directed learners (Fenty & Allio, 2017). However, these skills are often lacking in high school students, and absence of these skills should not exclude students from participation in AP courses (Fenty & Allio, 2017). Rather, AP courses may benefit from incorporating features to help build students' time management and self-directed learning skills (Fenty & Allio, 2017). Shaunessy-Dedrick and colleagues (2015) conducted interviews with struggling (n = 15) and successful (n = 15) AP (n = 19) and IB (n = 11) students in 2010 at six Florida schools to determine how students perceived benefits and disadvantages of advanced academic courses in high school. Students reported primary sources of stress were meeting various academic demands and finding a balance between academics, social life, and extracurricular activities; effective coping strategies for this stress included time management, temporary diversions, and cognitive reappraisal (Shaunessy-Dedrick et al., 2015). The two primary personality traits for success that emerged from the interviews were possessing a strong work ethic and high achievement motivation (Shaunessy-Dedrick et al., 2015). The identified coping responses and personal traits can partially explain how students deal with and perceive the demands of AP coursework, underscoring the importance of this study because little research has sought to understand the predictors of risk and success for students enrolled in advanced high school courses (Shaunessy-Dedrick et al., 2015). A final qualitative study of four high schools in one state aiming to describe relationships among student attitudes and AP courses conducted interviews and focus groups of 84 students who were enrolled in AP or IB courses (Foust et al., 2009). This was a rare study because it investigated student perceptions of nonacademic ramifications of participation in advanced academic courses (Foust et al., 2009). Students' perceived advantages of AP and IB participation compared to general education participation included better class atmospheres, more opportunities to form special bonds among peers, and greater pride and self-confidence from completing more challenging work (Foust et al., 2009). Students' perceived disadvantages included unflattering stereotypes, heavy workload, and additional stress and fatigue (Foust et al., 2009). Overall, research has indicated certain attitudinal traits (e.g., self-efficacy, high achievement motivation, and self-directed learning) may make AP students more likely to enroll in AP courses and more likely to experience success on AP exams or in AP coursework.

Family and peers. Student interactions with family and peers influence students' participation and success in AP courses (Flores & Gomez, 2011; Foust et al., 2009; Shaunessy-Dedrick et al., 2015; Walker & Pearsall, 2012; Weis & Cipollone, 2013). Research in this area investigates how family and peer microsystem factors influence student enrollment in AP courses (Flores & Gomez, 2011; Walker & Pearsall, 2012) and how families and peers play roles in the extent to which AP students achieve success and obtain associated benefits (Foust et al., 2009; Shaunessy-Dedrick et al., 2015; Weis & Cipollone, 2013).

Families and peers influence student participation in AP courses, particularly for traditionally underrepresented students (Flores & Gomez, 2011; Walker & Pearsall, 2012). A qualitative analysis of focus groups with four Latinx students and seven parent participants from one suburban, Western United States high school investigated policy, academic, and sociocultural factors which encourage and inhibit Latinx students from participating in AP courses (Walker & Pearsall, 2012). The authors hypothesized AP access policies were the major barrier to Latinx students' access to AP courses; however, social and cultural factors (i.e., peer relations and family support) were the most significant factors inhibiting Latinx AP participation. Additionally, Flores and Gomez's (2011) mixed methods investigation of strategies to increase AP participation for underrepresented students in California during the 2008-2010 school years identified the importance of informing families that AP is not only for top-performing students, to counteract any elitist misconceptions of the AP program and to increase families' awareness of benefits conferred by the AP Program (Flores & Gomez, 2011).

Peers and families may influence the extent to which students achieve success and obtain advantages associated from the AP program (Foust et al., 2009; Shaunessy-Dedrick et al., 2015; Weis & Cipollone, 2013). The previously described qualitative analysis of 84 AP and IB students from four high schools by Foust and colleagues (2009) investigated nonacademic advantages and disadvantages of AP enrollment. Improved bonds and relationships with peers were among the perceived benefits to AP courses (Foust et al., 2009). Scant research exists for nonacademic benefits of AP courses, but benefits of improved peer relationships may play a key role in students' overall health, success, and socioemotional development (Foust et al., 2009). Similarly, recall Shaunessy-Dedrick and colleagues' (2015) qualitative analysis of successful (n = 15) and struggling (n = 15) AP and IB students from six Florida schools in 2010. Part of that study sought to understand the social, familial, and educational supports and barriers that interacted with students' success in advanced coursework (Shaunessy-Dedrick et al., 2015). Support from peers, parents, and teachers were the most influential supports for AP and IB students, compared to other environmental factors, like educational supports (Shaunessy-Dedrick et al., 2015). A final study of family influences on advantages of AP courses for students was a qualitative investigation with students, parents, counselors, teachers, and administrators at two suburban, elite, affluent high schools in the Northeastern United States during the 2009-2010 school year (Weis & Cipollone, 2013). Investigators compared data from a public school (N = 37) to a private school (N = 38) to determine how parents of middle/upper class students used their social positions to maintain advantages for their children, particularly in the college admissions process (Weis & Cipollone, 2013). Private school and public school families utilized their social and economic capital to position themselves for continued advantage in competitive college admission processes (Weis & Cipollone, 2013). Drawing a contrast between the two schools, private school families actively pushed and prodded their children up to the end of the challenge for selective college admissions, whereas the public school families invested upfront in their children and then granted autonomy later in the process (Weis & Cipollone, 2013). Collectively, research indicates families and peers play an important role in encouraging students both to enroll in AP courses and to obtain available advantages and positive outcomes of AP coursework.

Prior knowledge. Students' mastery of prior academic content influences students' ability to learn new, related content at higher levels (National Research Council, 2002; Terry, de

La Harpe, & Kontur, 2016). Students have reported feeling underprepared to be successful in AP coursework (Hallett & Venegas, 2011; Walker & Pearsall, 2012) and research has quantitively demonstrated that increasing percentages of students are underprepared for success in AP courses (Hallett & Venegas, 2011; Judson & Hobson, 2015). This section presents evidence at the students' microsystem level of how students' prior knowledge influences their performance in AP courses. First, evidence of the importance of prior academic experience will be described, followed by possible justifications for why gaps in students' prior knowledge persist.

Prerequisite content knowledge is an important factor for students' success in the next level course (National Research Council, 2002; Terry et al., 2016). A two-year investigation by a National Research Council (2002) committee critically examined the status of AP mathematics and science programs. Students' prior academic experience was the primary factor leading to participation in AP mathematics and science courses (National Research Council, 2002). Furthermore, a quantitative analysis of approximately 3,000 students' course grades at the United States Air Force Academy from 2011 to 2013 provided evidence of how mastery of content-specific prior knowledge impacted learning in future courses (Terry et al., 2016). Researchers compared student course grades in a Physics II course to prior prerequisite and non-prerequisite course grades; they found students with strong prerequisite course grades earned higher scores in Physics II than students with weak prerequisite course grades (Terry et al., 2016). That learning gap, as measured by course exam scores, between students with strong prerequisite course grades and students with weak prerequisite course grades increased as the semester of Physics II progressed (Terry et al., 2016). Another correlation indicated as the average grade in the prerequisite courses increases, the average grade in Physics II exam grades increases; however, no correlation existed between student average grades in non-prerequisite freshmen English and

History courses and their Physics II grades, implying these results are specific for prerequisite courses and building learning progressions (Terry et al., 2016). This study emphasizes the importance of students being adequately prepared with content-specific prior knowledge before enrolling in advanced academic coursework, including AP courses.

Adequate preparation for AP coursework has been limited by early ability-tracking (Walker & Pearsall, 2012) and relatively low-quality academic experiences prior to and during AP courses (Hallett & Venegas; Judson & Hobson, 2015). Recall Walker and Pearsall (2012) found the major barriers to AP participation for Latinx students were peer relations and family support in their qualitative analysis of student (n = 4) and parent (n = 7) participants from one high school. However, additional factors that inhibited minority representation and achievement in AP courses included practices promoting early ability-tracking of students, due to which students tracked in low level courses may not have received the academic preparation required for success when they later advanced to AP courses (Walker & Pearsall, 2012). As described previously, the mixed methods study by Hallett & Venegas (2011) of highly-motivated, college-bound, low SES high school graduates investigated the quality of AP experience from students' perspectives. This study was based on a funds of knowledge theoretical framework, described by Stanton-Salazar (1997) as a reservoir of knowing what students must possess to successfully navigate complex systems. Hallett and Venegas (2011) applied this framework to the skills, connections, and knowledge high school students need to successfully transition to college. This study reported a low-quality AP experience, in part because students felt they were unprepared for AP coursework and unprepared for AP Exams during AP courses (Hallett & Venegas, 2011). Recall Judson and Hobson's (2015) robust analysis of national data from 1996-2012 that demonstrated a decrease in AP Exam performance correlated with the rapidly increasing AP enrollment over the study period. The authors explained students were sometimes limited in course selection options in schools where only AP and regular course offerings existed for a content area, possibly resulting in an increase of unprepared students in AP courses due to a limited supply of other course options for high-ability students (Judson & Hobson, 2015). Furthermore, speculating about causes of the declining AP Exam pass rate and increasing low-end AP Exam scores, Judson and Hobson proposed that as more students are encouraged to enroll in AP courses, students' average level of preparedness and skills required for AP coursework have declined. Additionally, teachers and administrators may perceive the purpose of AP courses as shifting more toward an experience of college-level coursework and away from earning passing scores on AP Exams (Judson & Hobson, 2015).

Collectively, studies related to student preparedness for AP courses demonstrate evidence of decreasing levels of preparedness for AP coursework. This under-preparedness is perhaps rooted in early ability-tracking practices which stream some students in low-level, less rigorous courses, which may result in students who later move up to AP courses being less prepared than their peers who have been participating in more advanced academic courses prior to AP courses. Overall, the literature indicates microsystem factors, such as student self-efficacy, motivation, stress, and prior knowledge, influence student preparedness and opportunities for academic success for AP students, particularly those students who are new to advanced academic coursework.

Summary

Since the 1990s, the purpose of the AP program has shifted from selectively admitting only top-performing students to providing all students, in particular historically underserved students, access to rigorous academic opportunities (Judson & Hobson, 2015). Macrosystem level factors of benefits of the AP program, access to AP courses, and success in AP courses interact with some students' inadequate preparation for AP coursework and influence their lack of success in AP courses (Cisneros et al., 2014; Judson & Hobson, 2015; McBride-Davis et al., 2015). Various federal, state, and local policies implemented in the late 1990s and thereafter were designed to improve access to AP courses for traditionally underserved students (Klugman, 2013; Judson & Hobson, 2015; Parker et al., 2013; Rowland & Shircliffe, 2016); however, implementing these exosystem policies may have produced unintended consequences (Klugman, 2013; Rowland & Shircliffe, 2016). At AP students' mesosystem, several characteristics of schools' AP Programs and AP teachers have interacted with student preparedness and success in AP courses: school characteristics that support or hinder AP access and performance, AP teacher background, and AP teacher practices. Among important microsystem factors that influence student preparedness and success in AP courses are student motivation to enroll in AP courses, student attitudinal factors (e.g., achievement motivation, self-efficacy, and self-determination), influences from family and peers, and student prior knowledge.

The literature discussed in this review indicates a need for better understanding of student preparedness for AP coursework and factors that influence students' success and challenges in AP courses. Accordingly, the needs assessment collected and analyzed existing data in one district to determine if the national trends in AP enrollment and success are also indicated in the context under investigation. Additionally, a qualitative investigation of AP teachers' perceptions of their students' preparedness to be successful in AP coursework, particularly in terms of self-efficacy, motivation, and prior knowledge, was helpful to identify to what extent these factors exist in the context under investigation. Extending this qualitative analysis to gather information about the professional preparation AP teachers have received, specifically for teaching AP courses, as well as instructional practices AP teachers perceive as enhancing or inhibiting student success in AP courses, facilitated a holistic understanding of student preparedness for AP courses and opportunities for success in AP courses.

Chapter 2: Empirical Examination of the Problem of Practice and Underlying Causes

This study was designed to investigate underlying causes and factors associated with student preparedness for Advanced Placement (AP) courses and associated student success in AP courses. First, this chapter will explain the purpose of the study. Next, the research questions of the study will be presented, followed by a detailed description of the procedures. Finally, a description of data and summary of results will be presented, laying the foundation for further investigation into the underlying causes and factors that influence student preparedness for AP courses and student success in AP courses.

Context of the Study

The context of this study was a county-wide school district in an east coast state that serves more than 113,000 students. The district was large (i.e., 682 square miles) and diverse, in terms of socioeconomic status (SES), race, and urbanicity. Regarding the district's diversity, the district was comprised of 44% of students qualifying for free and reduced-price meals, 13% of students receiving special education services, and 7% of students who are English language learners. The racial composition of students was 39% Black, 37% White, 11% Hispanic, 7% Asian, 5% two or more races, and 1% classified as other. Various communities in this school district were classified as urban, suburban, and rural. Table 2.1 compares demographic characteristics of the county under investigation to those of national, state, and other sample counties in the state using 5-year data profiles (2013-2017) obtained from the United States Census Bureau's American Community Survey ("American Community Survey," n.d.).

Table 2.1

National, State, and County Demographic Comparisons From 5-year (2013-2017) Data Profiles

	Race (%)[a]						SES ($)	Urbanicity[b]	
	White	Black	Hispanic	Asian	Amer. Indian	Other/ two or more races	Median Household Income	Urban	Rural
United States	61.5	12.3	17.6	5.3	0.7	2.5	57,652	80.7	19.3
State	51.9	29.3	9.6	6.2	0.2	2.9	78,916	87.2	12.8
County A[c]	58.7	27.5	5.1	5.9	0.2	2.4	71,810	93.5	6.5
County B	96.6	0.6	1.1	0.4	0.1	1.3	48,174	16.1	83.9
County C	45.0	17.6	19.0	14.7	0.1	3.6	103,178	97.6	2.4
County D	13.3	62.3	17.4	4.3	0.2	2.4	78,607	98.0	2.0

[a]Percents may not add up to 100% because of rounding
[b]Percent of total population in 2010
[c]The county under investigation

Purpose of the Study

Enrollment in AP courses has increased substantially from 1992-2012, and during that time, AP success (i.e., the portion of students earning passing scores on AP exams) has decreased (Judson & Hobson, 2015). AP students may continue to experience this recognized trend of decreased outcomes in AP courses unless the field improves its understanding of factors related to student preparedness and success in AP courses (Cisneros et al., 2014; Judson & Hobson, 2015; Klugman, 2013; Kolluri, 2018; McBride-Davis et al., 2015). The needs assessment provided an understanding of AP enrollment and AP exam scores throughout a large, diverse east coast state school district. Informal interviews were conducted with five AP teachers and two principals at five schools throughout the district to gain insight into AP teachers' and administrators' perceptions of factors related to the problem of practice and to establish the existence of the problem in the professional context being investigated. The needs assessment was designed to expand upon the perspectives of those participants and more deeply understand factors related to student preparedness and success in AP courses. This empirical study established to what extent decreasing preparedness for AP courses (Kolluri, 2018) and AP outcome trends described in other contexts (Cisneros et al., 2014; Judson & Hobson, 2015; Klugman, 2013; McBride-Davis et al., 2015) also exist in the school district under investigation. Additionally, this study was intended to gain insights into AP teachers' and school administrators' perceptions of their AP students' ability to be successful in AP courses, specifically in terms of self-efficacy, motivation, and prior knowledge. To gain understanding of factors affecting AP students' preparedness and success in AP courses, this study investigated how AP teachers and school administrators described AP teachers' professional preparation to teach AP courses and the instructional practices teachers and administrators perceived as enhancing or inhibiting student preparedness and success in AP courses.

Research Questions

Answers to these research questions for this needs assessment helped describe the factors related to student preparedness for success in AP courses, specifically in the five diverse schools within the school district under investigation:

1. How has overall AP enrollment changed annually from the 2014-2015 school year to the 2016-2017 school year?
2. How have AP exam scores changed annually from the 2014-2015 school year to the 2016-2017 school year?
3. What are AP teachers' and principals' perceptions of their students' ability to be successful in AP coursework?

4. How do AP teachers and principals describe their professional development preparation for teaching AP courses?
5. What instructional actions have teachers taken to address student success in AP coursework?
6. To what degree are AP teachers in different content areas similarly prepared to provide effective instruction for success in AP courses?

This multi-methods study investigated factors related to student preparedness and success in AP courses. This investigation identified factors in the context that contribute to student preparedness for success in AP courses, including student prior knowledge, student self-efficacy, influences from students' family and peers, student motivation, teachers' instructional practices, and teacher capacity to effectively teach AP students. This study increased understanding of how these student and teacher-level factors may interact with student success in AP courses. Success, in this context, may include AP exam scores, AP course grades, other academic benefits (e.g., improved learning strategies), and non-academic benefits (e.g., improved peer relationships). This study also documented teachers' and school administrators' perceptions of local, state, and federal policies aimed at increasing access to rigorous AP courses for all students, and how those policies may interact with their students' preparation and success in AP courses. Additionally, this study provided an analysis and description of the districts' AP enrollment and AP exam scores from 2014 to 2017. Improved understandings of these factors and how they relate to the problem of practice can inform future initiatives to optimally prepare AP teachers to better support students for success in AP courses.

Method

This section will first describe an overview of the research design of this multi-method study. The quantitative component of this study analyzed existing data of AP enrollment and AP exam scores from 2014 to 2017 from each of five high schools within the school district being investigated. Semi-structured interviews were conducted with AP teachers and school principals at the same five high schools to provide qualitative data for this study. This section will then include descriptions of the participants, measures and instrumentation, and procedures for this study. A research summary plan matrix is presented in Appendix A.

Research Design

The unit of analysis for this study was individual. AP teachers and school administrators of schools with AP programs comprised the participants in this study. The scope of the qualitative component of this study included one AP teacher from each of five high schools with diverse enrollment profiles and one school administrator from each of two high schools in the district. These participants were selected from five schools that have a range of success and robustness of their AP programs according to their publicly available state department of education school report card profile. Qualitative methods for this study included semi-structured interviews with the five AP teachers and two school administrators.

The quantitative component of this study included an analysis of existing AP enrollment data and AP exam results for the three school years (i.e., 2014-2015, 2015-2016, and 2016-2017) for the same five schools within the district where interviews were conducted with AP teachers and administrators. The AP enrollment data included both the number of students enrolled in at least one AP course and the sum of AP enrollment per school, which accounts for some students who enroll in multiple AP courses (e.g., a student enrolled in two AP courses contributes two enrollments). For each of the five schools under investigation, the AP exam data included the total number of AP exams taken and the AP exam score distributions. Collectively, this investigation gathered information and perceptions that inform a picture of factors influencing student preparedness and success in AP courses in the district under investigation.

Sample and participants. The quantitative analysis of this investigation was conducted on existing data provided by the district. AP enrollments (i.e., the number of students enrolled in AP courses each school year and the sum of all AP enrollment per school) were analyzed for three consecutive school years; 2014-2015, 2015-2016, and 2016-2017 to describe changes in AP enrollment over the three school years. Additionally, the number of AP exams taken each year per school and the AP exam scores (i.e., 1, 2, 3, 4, 5, with 5 representing the highest possible score) were analyzed to describe changes in AP success on AP exams over the same three school years.

Participants in the qualitative analysis included five AP teachers who had at least five years of experience teaching an AP course from five diverse—in terms of the schools' robustness and success of their AP program—high schools. Two additional participants, school administrators who had at least three years of experience as principal of their school—which has maintained a continually operating AP Program for at least 10 years—were included in this analysis because their role as school leaders offered holistic perspectives of the role, success, and limitations of the AP program at their schools. The five high schools were strategically selected using purposive sampling (Lochmiller & Lester, 2017) to represent a range of academic profiles according to their publicly available state department of education report cards (Table 2.2). The five AP teachers were selected to represent a variety of content areas,

Table 2.2

School Ranking Measures Compared to State Means, According to the State Department of Education Report Card Profiles

School	Overall ranking relative to state mean	Academic achievement ranking relative to state mean
School A	-10%	-12%
School B	+10%	+18%
School C	-6%	-16%
School D	-3%	-9%
School E	+15%	+20%

which were indicated on their schools' publicly available staff directory. The five AP teachers and two school administrators were selected because they possessed perspectives which could inform the underlying causes and factors related to student preparedness and success in AP courses. The range of content areas taught and years of experience for all participants is represented in Table 2.3.

Table 2.3

Participants' Characteristics

Participant	Position	AP content area taught	Years of experience teaching an AP course	Total years of experience in education	Years of experience as a school administrator
A	Teacher	Spanish	14	16	NA
B	Teacher	Biology	7	10	NA
C	Teacher	Environmental Science	10	17	NA
D	Teacher	World History	10	21	NA
E	Teacher	English	11	22	NA
F	Principal	NA	NA	21	8
G	Principal	NA	NA	24	9

The quantitative data in this investigation described AP enrollment and AP success (i.e., AP exam scores) from the three school years between 2014 to 2017 from five schools selected using stratified sampling (Lochmiller & Lester, 2017). These quantitative data were assumed to represent state-wide trends in AP enrollment and AP success. The quantitative data may be generalizable to the state level, considering Maryland has only 24 school districts; however, generalizability may be limited because those 24 districts vary demographically, as shown in Table 6. Due to various state policies regarding AP access, incentives, and enrollment, generalizability of these quantitative data beyond the state level is not practical. The qualitative data obtained from the seven participants was collected to represent perspectives of AP teachers and administrators in the district under investigation. However, generalizing participant perspectives related to preparedness and success in AP courses to the district level may be limited because seven participants may not reflect the perspectives of all AP teachers and administrators throughout the large district.

Measures and instrumentation. This section describes the quantitative measure of existing AP enrollment and AP exam score data for the district and then the qualitative measure of semi-structured interviews. The constructs that were measured, construct definitions, and how constructs were operationalized are included in the descriptions of measures.

AP enrollment and AP exam scores data*.* Existing district data included two measures of AP enrollment and AP exam scores. The two AP enrollment variables are defined as the number of students enrolled in at least one AP course and the total number of enrolled seats in AP courses; for example, a student enrolled in two AP courses contributed two enrollments (Klugman, 2013). AP exam scores are an ordinal level, whole number variable ranging from the lowest possible score of 1 to the highest possible score of 5 (College Board, 2014). Descriptive statistics and Chi Square tests were used to analyze existing AP enrollment and AP exam scores for each of the three years—by school and compositely for all five schools investigated—to describe the trends in AP participation and success in AP courses over the study period in the district under investigation, addressing the first two research questions.

Semi-structured interview data. Researcher-created semi-structured interview questions were used to attend to the final four research questions through the perceptions of experienced AP teachers (Appendix B) and school administrators (Appendix C) who oversee AP programs. The semi-structured interviews also provided insight into the AP enrollment and AP exam score changes over time. In attempts to achieve credibility and dependability of the qualitative strand of the study, the interviews were piloted (Lochmiller & Lester, 2017) with two AP teachers and cognitive interviews (Desimone & Le Floch, 2004) were conducted. The following constructs are defined and operationalized in this section, as they serve as a priori codes: student self-efficacy, student self-determination, student achievement motivation, student prior knowledge, AP teacher background, and AP teacher instructional practices.

Perceptions of AP teachers and school administrators were analyzed following semi-structured interviews to gain an understanding of students' perceived ability and preparedness for AP coursework. Student self-efficacy is students' belief in themselves that they can achieve well academically (Bryan et al., 2011). Student self-efficacy may influence whether students enroll in AP courses and their eventual success in the AP course. Student self-determination refers to students' perceptions of the control they possess over their own learning (Bryan et al., 2011). Self-determination may interact with academic outcomes of AP courses for students. Student achievement motivation is the internal drive that begins, directs, and maintains goal-oriented behavior (Bryan et al., 2011). Achievement motivation may have a significant influence on students' decision to enroll in AP courses and the success they achieve in AP courses. Student prior knowledge refers to the content-specific understanding a student possesses when entering an AP course (National Research Council, 2002). Student prior knowledge may be an important component of student preparedness for AP coursework and may influence success in AP courses. AP teacher background describes the training, qualifications, knowledge, and preparation a teacher possesses to instruct an AP course (Milewski, 2002). The professional background of AP teachers may influence their capacity to effectively instruct AP courses and prepare students for success in their AP course. Teacher practices include any pedagogical and instructional methods and strategies used in teaching a class (Fischer et al., 2018a). Instructional practices used by AP teachers may interact with how well students are prepared for success in AP courses. Innovative instructional practices that shift away from teacher-centered lessons and toward student-centered lessons may influence AP student experiences and AP success, such as flipped classroom models (Schultz et al., 2014), project-based lessons (Parker et al., 2013), inquiry-based science lesson (Fischer et al., 2018a), and cross-curricular strategies (Flores & Gomez, 2011). Collectively, an analysis of these defined and operationalized constructs contributed to an improved understanding of factors related to student preparedness and success in AP courses in the particular context.

Sample questions from the semi-structured interviews are provided in Table 2.4. A full list of semi-structured interview questions for AP teachers and school administrators is provided in Appendices B and C, respectively. The appendices include follow-up and probing questions that were not all included in all interviews.

Table 2.4

Sample Semi-Structured Interview Questions for AP Teachers and School Administrators

Target participants	Sample semi-structured interview questions
AP teachers with more than five years of experience teaching an AP course	Over time, what, if any, changes have you noticed changes in the academic preparedness of students in your AP courses? What have you noticed about the characteristics of students who are successful in your school's AP courses or characteristics of students who are unsuccessful? What instructional practices do you find most successful in your AP course?
School administrators who oversee an AP Program	How do you feel about efforts to increase AP enrollment? What training or background do you feel is important for AP teachers to be successful? How does student preparedness for AP courses now compare to student preparedness 10 years ago?

This study investigated the interaction between the microsystem factors described above and student preparedness and success in AP courses. Sample interview questions that were intended to provide teacher and school administrator perspectives are presented in Table 9. The questions presented in Table 2.5 were open-ended to minimize bias but were followed up with probing questions to more directly access perspectives of each construct. Notably, there are additional factors that may influence student preparedness and success in AP courses that are not measured in this study. These factors include influences of family and peers on AP students and certain school infrastructure characteristics that may influence student preparation for AP courses and teacher capacity to instruct AP courses (i.e., school size, class size, and teachers' course assignments).

Table 2.5

Sample Semi-Structured Interview Questions Intended to Address Each Construct

Construct	Sample semi-structured interview question
Self-efficacy, Self-determination, and Motivation	What skills or characteristics do you think are essential for student success in your AP course once they are in your class?
Prior knowledge	What preparation or prior coursework do students in your AP course experience?
AP teacher background	In teaching your AP course, what training has best supported you to prepare your students
Teacher practices	What components have you added to your AP courses over the years to support student success?

Procedure. This section will first describe the data collection methods for obtaining existing data and qualitative data. Then, the data analysis methods will be presented.

Data collection methods. The quantitative analysis of this investigation was conducted on existing data obtained from the school district's data warehouse with the approval of the district institutional review board (IRB). AP enrollment data and AP exam scores were requested for three years, which is the maximum number of years allowed by the district IRB. Although data from nonconsecutive years may better describe trends in AP enrollment and AP exam scores over time, only data from three consecutive years was available.

To collect qualitative data, recruitment emails (Appendix D) were directly sent to AP teachers at each high school; teacher email addresses were obtained from school websites. From the pool of AP teachers who volunteered to participate, experienced AP teachers (i.e., more than five years of teaching an AP course) were strategically selected to represent various content areas. Recruitment emails (Appendix E) were also directly sent to two school principals at schools with robust AP programs that have been active for at least ten consecutive years. The overall response rate to recruitment emails was 42%. Appropriate cautions and safeguards were implemented to ensure the privacy and protections of all participants. Semi-structured interviews lasted between 45-60 minutes and were conducted in person at each participant's place of employment. Semi-structured interviews were audio-recorded and transcribed using Otter.ai speech to text software; handwritten notes were taken, scanned into electronic documents, and the paper handwritten notes were destroyed. All electronic documents (i.e., AP enrollment data, AP success data, scanned interview notes, interview audio files, and interview transcripts) were stored on a password-protected computer that only the researcher has access to; all electronic data documents will be deleted in seven years.

Data analysis. The existing quantitative data were described and then analyzed using Chi Square tests to indicate changes in AP enrollment and AP exam scores over the three years studied. To investigate the change in AP enrollment and the number of AP exams taken over the three years studied at the five schools, four variables were compared across the schools and years: (a) number of students enrolled in at least one AP course, (b) the sum of AP enrollment (i.e., seats) for all classes, (c) the number of AP exams taken, and (d) the total school enrollment. The total school enrollment data were used to determine to what degree the growth or decline of AP enrollment and AP exams taken could be attributed to changes in the schools' overall enrollment. To investigate the change in AP success, as measured by AP exam scores, the distribution of AP exams scores was analyzed at the school level. The AP exam pass rate was determined by dividing the number of AP exams on which students scored a 3, 4, or 5 by the total number of AP exams taken. Comparisons of changes in AP enrollment and AP exam scores were described for each of the five schools and Chi Square tests indicated changes to AP enrollment and AP exam scores over the three years studied.

The analysis of the interview data began with organizing the data and deidentifying the transcripts. Then, descriptive coding was applied to the transcripts (Miles, Huberman, & Saldaña, 2014). The initial round of data analysis involved deductive coding, as suggested by Miles, Huberman, and Saldaña, (2014), and included a priori codes derived from the conceptual framework and literature review for motivation, self-efficacy, background knowledge, PD, and teacher practices. Additional codes emerged from the data (i.e., inductive coding) upon multiple cycles of coding, which included open access, recruit students, lower level classes, college admissions, unintended consequences, minimal emphasis, access misconception, varying skill levels, varying academic experiences, teachers' mindsets, teaching introductory courses, studying strategies, negative experiences, isolation, vertical teaming, APSI, APTC, PLC, positive deviants, inquiry-based learning, and focused immediate preparation. The complete codebook is presented in Appendix F. Following immersion in the data (i.e., repeated reading and coding cycles; Braun & Clarke, 2006), codes were refined and analysis revealed themes (i.e., commonalities across codes). The codes and themes presented in Appendix F were checked for credibility through peer scrutiny, as suggested by Shenton (2004). Finally, connections were drawn between themes and the research questions to develop the key findings of the qualitative component of this study and better understand factors that influence student preparedness for AP courses and student success in AP courses.

Findings and Discussion

This section will explain the results obtained from the needs assessment and discuss the implications of these findings as pertaining to the research questions. First, key findings from the quantitative strand of the study will be presented and discussed, followed by the observations and discussion of the qualitative semi-structured interviews. Finally, a summary of the results will be presented and limitations of the study will be acknowledged.

Key Findings From the AP Enrollment and AP Exam Score Data

This section first presents descriptive statistics for AP enrollment and AP exam scores from 2014-2017 as a composite of the five schools investigated, as well as individually for each school. Then, the percent change of AP enrollment (composite and individual schools) will be discussed to address the first research question: How has overall AP enrollment changed annually from the 2014-2015 school year to the 2016-2017 school year? Finally, the change in AP exam pass rates (composite and individual schools) will be discussed to address the second research question: How have AP exam scores changed annually from the 2014-2015 school year to the 2016-2017 school year?

Descriptive statistics of AP enrollment. This section describes the AP enrollment in the five high schools investigated from 2014 to 2017. The variables indicating AP enrollment are presented in Table 2.6 and include the number of students enrolled in at least one AP course, the sum of AP enrollment for all classes, the number of AP exams taken, the percent of students enrolled in at least one AP course, and the total school enrollment as of 2018, as a reference of school size.

Table 2.6

Measures of AP Enrollment From 2014 to 2017 by School

School	Academic year	Total school enrollment	Students enrolled in at least one AP course	Percent of students enrolled in at least one AP course	Sum of AP enrollment for all classes	Number of AP exams taken
School A	2014-2015	991	217	21.9	358	193
	2015-2016	1,005	157	15.6	263	184
	2016-2017	965	159	16.5	251	162
School B	2014-2015	1,803	709	39.3	1,843	1,790
	2015-2016	1,851	773	41.8	1,981	1,905
	2016-2017	1,828	754	41.2	1,916	1,815
School C	2014-2015	1,519	211	13.9	356	291
	2015-2016	1,491	267	17.9	384	321
	2016-2017	1,351	210	15.5	319	264
School D	2014-2015	1,434	278	19.4	460	299
	2015-2016	1,463	271	18.5	492	310
	2016-2017	1,467	310	21.1	548	265
School E	2014-2015	1,444	634	43.9	1,646	1,303
	2015-2016	1,482	747	50.4	1,915	1,377
	2016-2017	1,509	795	52.7	2,079	1,433

As shown in Table 2.6, the five schools varied in measures of AP enrollment during the three years studied. Further, one school (school A) showed a decrease in AP enrollment, two schools (Schools B and C) showed no clear pattern of AP enrollment, and two schools (Schools D and E) showed a general increase in AP enrollment. Further, the percent of students enrolled in at least one AP course varied considerably among the five schools, with schools B and D having enrolled greater percentages of students in AP courses than schools A, C, and E.

Table 2.7 shows AP enrollment measures as a composite for all five high schools combined. The variables indicating AP enrollment include the number of students enrolled in at least one AP course, the sum of AP enrollment for all classes, the number of AP exams taken, the number of AP exams taken per student enrolled in the school, and the total enrollment of the schools in 2018.

Table 2.7

Composite Measures of AP Enrollment for all Five Schools

Academic year	Total student enrollment	Students enrolled in at least one AP course	Percent of students enrolled in at least one AP course	Sum of AP enrollment for all classes	Number of AP exams taken
2014-2015	7,191	2,049	28.5	4,663	3,876
2015-2016	7,292	2,215	30.4	5,035	4,097
2016-2017	7,120	2,228	31.3	5,113	3,939

As indicated in Table 2.7, the number of students enrolled in at least one AP course and the sum of AP enrollment for all classes increased incrementally over the three years. Fluctuations in the number of AP exams taken, the number of AP exams taken per student enrolled in the school, and the schools' total enrollment were observed over the three years. The extent to which these changes in AP enrollment were measured are analyzed following the presentation of AP exam score data.

Descriptive statistics of AP exam scores. This section describes the number of AP exams taken and the number of AP exams passed from AP exams taken in 2015, 2016, and 2017. Table 2.8 shows these measures by school.

Table 2.8

Number of AP Exams Taken and Passed in all Five Schools per Year

School	Academic year	Number of AP exams taken	Number of AP exams passed[a]
School A	2014-2015	193	59
	2015-2016	184	31
	2016-2017	162	27
School B	2014-2015	1790	1492
	2015-2016	1905	1572
	2016-2017	1815	1480
School C	2014-2015	291	45
	2015-2016	321	61
	2016-2017	264	47
School D	2014-2015	299	111
	2015-2016	310	108
	2016-2017	265	90
School E	2014-2015	1303	1032
	2015-2016	1377	1085
	2016-2017	1433	1124

[a]Passing scores on AP exams are ≥ 3 on a 1 to 5 scale

As shown in Table 2.8, the five schools varied in the number of AP exams taken and passed. Schools B and E took and passed more AP exams than Schools A, C, and D.

Table 2.9 describes the number of AP exams taken and the number of AP exams passed from AP exams taken in 2015, 2016, and 2017 as a composite of all five schools investigated.

Table 2.9

Composite Number of AP Exams Taken and Passed

Academic year	Number of AP exams taken	Number of AP exams passed[a]
2014-2015	3,876	2,739
2015-2016	4,097	2,857
2016-2017	3,939	2,768

[a]Passing scores on AP exams are ≥ 3 on a 1 to 5 scale

As shown in Table 2.9, the number of AP exams taken increased from year one to year two, but decreased from year two to year three. The number of AP exams passed followed the same pattern. The potential of total school enrollment moderating these variables will be discussed later.

Change in AP enrollment from 2014 to 2017. This section discusses the magnitude of AP enrollment change over the three-year study period in the five schools individually and compositely. Data is analyzed using the percent change of several measures of AP enrollment growth or decline, of which the sum of AP enrollment for all classes—arguably the most direct measure—is analyzed using a Chi Square test to indicate the overall change in AP enrollment in the district.

Table 2.10 presents the percent change in AP enrollment from the previous year by school. The variables presented in Table 2.10 include the percent change of: the number of students enrolled in at least one AP course, the sum of AP enrollment for all classes, and the number of AP exams taken.

Table 2.10

Percent Change From Previous Year in Growth or Decline of AP Enrollment by School

School	Academic year	Total school enrollment	Percent change of the number of students enrolled in at least one AP course	Percent change of the sum of AP enrollment for all classes	Percent change of the number of AP exams taken	Number of AP exams taken per student enrolled in the school
School A	2014-2015	991	-	-	-	0.19
	2015-2016	1005	-6.1%	-9.6%	-0.9%	0.18
	2016-2017	965	+0.2%	-1.2%	-2.2%	0.17
School B	2014-2015	1,803	-	-	-	0.99
	2015-2016	1,851	+3.5%	+7.7%	+6.4%	1.02
	2016-2017	1,828	-1.0%	-3.5%	-4.9%	0.99
School C	2014-2015	1,519	-	-	-	0.19
	2015-2016	1,491	+3.7%	+1.8%	+2.0%	0.22
	2016-2017	1,351	-3.8%	-4.4%	-3.8%	0.20
School D	2014-2015	1,434	-	-	-	0.21
	2015-2016	1,463	-0.5%	+2.2%	+0.8%	0.21
	2016-2017	1,467	+2.7%	+3.8%	-0.4%	0.18
School E	2014-2015	1,444	-	-	-	0.90
	2015-2016	1,482	+7.8%	+18.6%	+5.1%	0.93
	2016-2017	1,509	+3.2%	+11.0%	+3.8%	0.95

As shown in Table 2.10, individual schools varied in the magnitude in which their AP enrollments increased or decreased. School A demonstrated a general decline in AP enrollment over the three years. Schools B and C increased AP enrollment from year one to year two, but then decreased AP enrollment from year two to year three. School E—and to a lesser extent School D—increased AP enrollment over the three years, as indicated by the percent changes in AP enrollment measures.

Table 2.11 presents measures of growth or decline of AP enrollment as a composite for all five schools. The percent change from the previous year is indicated for: the total school enrollment, the number of students enrolled in at least one AP course, the sum of AP enrollment for all classes, and the number of AP exams taken. The number of AP exams taken per student enrolled in the school serves as an additional measure of AP enrollment change.

Table 2.11

Measures of Growth or Decline of AP Enrollment as a Composite for all Five Schools

Academic year	Total student enrollment	Percent change in total student enrollment	Percent change of the number of students enrolled in at least one AP course	Percent change of the sum of AP enrollment for all classes	Percent change of the number of AP exams taken	Number of AP exams taken per student enrolled in the school
2014-2015	7,191	-	-	-	-	0.54
2015-2016	7,292	+1.4%	+2.3%	+5.2%	+3.1%	0.56
2016-2017	7,120	-2.4%	+0.2%	+1.1%	-2.2%	0.55

Table 2.11 demonstrates AP program growth or decline over the study period for all five high schools combined. The number of students enrolled in at least one AP course increased by 2.3% from the first to second year of the study and 0.2% from the second to third year of the study. The total enrollment for all AP courses increased by 5.2% from the first to second year of the study and by 1.1% from the second to third year of the study. Although the number of AP exams taken increased by 3.1% from the first to second year of the study, AP exam taking decreased by 2.2% from the second to third year of the study. The number of AP exams taken per student in the school increased after year one. The overall growth in the AP program in the school district is suggested by the general increases in measures of AP enrollment growth shown in Table 2.11.

Table 2.7 shows the sum of AP enrollment for all classes—perhaps the most direct measure of AP enrollment—increased from 2014-2015 ($N = 4{,}663$) to 2015-2016 ($N = 5{,}035$) to 2016-2017 ($N = 5{,}113$) for the five schools under study. The number of global AP exam test takers increased by 5.14% from the first to second year of the study and by an additional 4.99% from the second to third year of the study (College Board, 2018). Using those global increases in AP exam takers to predict the increase in AP enrollment for all classes in the five schools investigated, Chi Square analysis indicated AP enrollment in the five schools increased significantly more than expected over the study period, (X^2 [1, $N = 5{,}113$] = 9.23, $p = .0024$. Collectively, these findings addressed the first research question: Despite only analyzing three consecutive years of AP enrollment data, the number of students enrolled in AP courses from 2014 to 2017 increased substantially in the district.

Change in AP exam pass rate from 2015 to 2017. This section analyzes two measures of AP exam scores, AP exam pass rate and mean AP exam score, from AP exams taken in 2015, 2016, and 2017. Table 2.12 shows these measures of AP performance annually by school.

Table 2.12

AP Exam Success in all Five Schools per Year

School	Academic year	AP exam pass rate (%)	Mean AP exam score
School A	2014-2015	30.6	2.04
	2015-2016	16.8	1.79
	2016-2017	16.7	1.72
School B	2014-2015	83.4	3.67
	2015-2016	82.5	3.67
	2016-2017	81.5	3.59
School C	2014-2015	15.5	1.63
	2015-2016	19.0	1.77
	2016-2017	17.8	1.75
School D	2014-2015	37.1	2.22
	2015-2016	34.8	2.16
	2016-2017	34.0	2.15
School E	2014-2015	79.2	3.50
	2015-2016	78.8	3.51
	2016-2017	78.4	3.45

The AP exam pass rate for each school per year was determined by dividing the number of AP exams passed by the total number of AP exams taken. This measure of AP success shown in Table 2.12 did not statistically change over the three years studied for School B (X^2 [1, N = 1,905] = 0.38, p = .54), School C (X^2 [1, N = 321] = 2.74, p = .10), School D (X^2 [1, N = 310] = 0.48 , p = .49), nor School E (X^2 [1, N = 1,433] = 0.05, p = .82). However, School A, demonstrated a significant decrease in its pass rate over the study period (X^2 [1, N = 193] = 11.37, $p < .001$). Another measure of AP exam success, school's mean AP exam score, was calculated from the AP exam score distribution per school per year. As with the AP exam pass rate, only School A demonstrated a decrease in its mean AP exam score over the three years, whereas the other four schools' mean AP exam score held relatively constant over the study period. Interestingly, the only school investigated that demonstrated a decrease in AP exam performance (School A) was also the only school that demonstrated a decrease in AP enrollment, as previously described.

Table 2.12 indicates differences in performance on AP exams among schools. For example, schools B and E had AP exam pass rates that ranged from 78.4% to 83.4%, whereas AP exam pass rates ranged from 15.5% to 37.1% for schools A, C, and D. Similarly, schools B and E had a relatively high range of mean AP exam scores (3.45 to 3.67) compared to schools A, C, and D (1.63 to 2.22). These performance differences between schools are not surprising considering the diverse range of academic profiles of the five schools according to their 2017-2018 state department of education report card profiles. Nonetheless, the relatively low AP exam pass rates in some schools indicates a need to better prepare and support AP students and teachers for success.

Table 2.13 shows two measures of AP exam success—AP exam pass rate and mean AP exam scores—compositely for the five schools by year.

Table 2.13

AP Exam Success in all Five Schools per Year

Academic year	AP exam pass rate (%)	Mean AP exam scores
2014-2015	70.7	3.26
2015-2016	69.7	3.27
2016-2017	70.3	3.24

Despite a decrease in AP exam scores during the three years, the AP exam pass rates shown in Table 2.13 were not statistically different in the five representative high schools for the district, X^2 (1, N = 4,097) = 0.73, p = .39. Likewise, the mean AP exam scores for all five schools combined held generally consistent over the three years studied. Therefore, these findings addressed the second research question: Perhaps due to the limitation of only analyzing three consecutive years of data, there was no evidence to indicate AP exam scores have significantly decreased in the district under study. Further, the relatively high pass rates in Schools B and E may have masked the lower pass rates in Schools A, C, and D; this may have concealed the need for enhanced supports for AP teachers in some schools to better prepare AP students for success.

The global pass rate for AP exams for each of the three years studied was 58.0% (College Board, 2018). Comparing that global pass rate to the AP exam pass rates for the district under study indicated the district scored higher on AP exams than the entire AP population over the three years (X^2 [1, N = 4,097] = 393, $p < .001$).

Table 2.14 aligns measures of AP exam performance (i.e., AP exam pass rate and mean AP exam score) with measures of AP enrollment (i.e., percent of students enrolled in at least one AP course and the average number of AP courses taken per AP student).

Table 2.14

AP Exam Performance Aligned With Relative AP Enrollment per School

School	Academic year	Percent of students enrolled in at least one AP course	Average number of AP courses taken per AP student	AP exam pass rate (%)	Mean AP exam score
School A	2014-2015	22.1%	1.6	30.6	2.04
	2015-2016	16.0%	1.7	16.8	1.79
	2016-2017	16.2%	1.6	16.7	1.72
School B	2014-2015	37.7%	2.6	83.4	3.67
	2015-2016	41.1%	2.6	82.5	3.67
	2016-2017	40.1%	2.5	81.5	3.59
School C	2014-2015	17.1%	1.7	15.5	1.63
	2015-2016	21.7%	1.4	19.0	1.77
	2016-2017	17.0%	1.5	17.8	1.75
School D	2014-2015	19.3%	1.7	37.1	2.22
	2015-2016	18.8%	1.8	34.8	2.16
	2016-2017	21.5%	1.8	34.0	2.15
School E	2014-2015	38.9%	2.6	79.2	3.50
	2015-2016	45.9%	2.6	78.8	3.51
	2016-2017	48.8%	2.6	78.4	3.45

Table 2.14 indicates that the schools with higher AP enrollment measures also demonstrate relatively high measures of AP exam performance. This relationship raises questions about the levels of supports provided for AP students and teachers among the schools, and the levels of pressure to enroll and succeed in AP courses among the schools, which are examined through qualitative measures.

Key Observations and Discussion From the Qualitative Analysis

The interviews conducted with AP teachers and principals allowed for a deeper investigation into the research questions. This section will discuss the themes and codes that emerged from the interview data, which are identified and defined in Table 2.15 (see Appendix F for aligned examples), as pertaining to the research questions. This section is organized by six themes: efforts to increase AP enrollment, AP exam pass rates, differences in students' prior knowledge, collaboration, professional learning (PL), and instructional strategies.

Table 2.15

Final Themes, Codes, and Definitions From the Qualitative Analysis

Theme	Code	Definition
Efforts to increase AP enrollment	Recruit students	An active effort by schools and teachers to encourage increasing numbers of students to enroll in AP courses
	Open access	A school action of removing prerequisites for AP courses as part of efforts to increase AP enrollment
	Lower-level classes	Standard and honors level courses, as opposed to the advanced academic track, gifted and talented (GT)
	College admissions	The ways that the college admissions process influences student enrollment in AP courses
	Unintended consequences	Unforeseen negative side effects of efforts to increase AP enrollment
AP exam pass rates	Minimal emphasis	The relatively low level of importance placed on AP exam pass rates compared to increasing AP enrollment
	Access misconception	A prevalent misconception in schools that mere exposure to AP courses will result in improved student outcomes
Differences in students' prior knowledge	Varying skill levels	The diverse range of academic skills demonstrated by AP students
	Varying academic experiences	The diverse educational history experienced by AP students
	Teachers' mindset (regarding differences in student prior knowledge)	How teachers perceive the increasingly diverse academic profile of AP classes
	Content-specific test-taking skills	Skills students may apply to improve success on disciplinary assessments
	Teaching introductory courses	Opportunity to groom students for AP because the teacher knows what skills and knowledge are needed for AP
	Studying strategies	Skills and techniques students apply to enhancing learning, memory, and transfer
Collaboration	Negative experiences	Previous ineffective collaboration with colleagues
	Isolation	The sense of having limited collaboration opportunities due to being the only content-specific AP teacher in a school
	Vertical teaming	Collaboration among teachers of various grade levels, which can align content, expectations, skills, and knowledge for students as they progress through grade levels
Professional Learning	Advanced Placement Summer Institute (APSI)	A week-long, intensive summer training program sponsored by the College Board to prepare teachers for instructing specific AP content area courses
	Advanced Placement Teacher Community (APTC)	An online resource available to all AP teachers, which provides opportunities for collaboration through online discussion boards and resource sharing
	Professional learning community (PLC)	A group of educators who collaborate regularly to share expertise and work to improve teaching skills and student outcomes
	Positive deviants	AP teachers whose behaviors result in substantially better outcomes compared to similar peers
Instructional strategies	Inquiry-based learning	A form of student-centered, active learning in which students often pose questions, solve problems, and construct their own learning (e.g., project-based lessons and flipped lessons)
	Focused immediate preparation	Summer training programs designed to prepare incoming AP students for the rigorous coursework and expectations of their upcoming AP course

Efforts to increase AP enrollment. All seven participants described efforts in their school to increase AP enrollment during their tenure as an AP teacher or administrator. A code that emerged in this theme is *student recruitment*, which is an active effort by schools and teachers to encourage increasing numbers of students to enroll in AP courses. Participants described causes, mechanisms, benefits, and drawbacks of escalating recruitment efforts in recent years. Principal F framed a major cause of the impetus to begin recruiting students to the AP Program to increase enrollment:

> When I was assistant principal, at one point, about 2007, the superintendent made an edict, every high school in [the district] would offer at least 13 AP course offerings. And so for the school that I was in at the time, that was not the case. So we ended up, you know, putting these courses out there that we had not previously offered, trying to get teachers ready to deliver them, and then also trying to convince, you know, the school to push enrollment.

Teacher C explained these recruitment efforts are not equal across all content areas: “We have tried to increase enrollment in AP classes, some more than others.” Teacher B described the mechanisms of recruiting students: “There has been a big push to increase enrollment. We go around, talk to students, talk to classes of all levels, send information home to parents.” Principal F proudly explained their school’s accomplishment in this area: “Our goal is to increase access…over the past five years, we’ve increased the number of test takers and tests given.” Despite being willing to actively recruit students, some AP teachers held reservations regarding those efforts: “We strongly encourage these kids to take AP classes, even though they quite weren’t [*sic*] ready for the class” (Teacher A). Teacher D shared a similar notion regarding recruiting students:

> I started with one section, and I worked my way up to two sections. And I'm trying to recruit kids from all levels. And, you know, going through that diversity piece, and I don't know if we've really hit the mark on that. But I see a difference in the kids that I'm kind of recruiting, you know, they need...something. But I kind of thought it was important to make all the kids that take either living systems, or back then bio, feel welcome to try to take it, right. And that may have hurt my test scores.

All participants spoke to recent efforts in their school to increase AP enrollment; however, while acknowledging the likely value of bringing more students into the AP Program, some teachers describe some drawbacks that may be associated with recruiting students—notably less prepared students. Some participants offered insight into school policy adjustments that allowed more students to enter AP courses.

In the early 2000s, many schools in the district had prerequisites for students to enter AP courses. However, apparently corresponding with the superintendent's 2007 edict (Principal F), many schools removed prerequisites as a mechanism to bring more students into the AP Program, leading to the code, *open access*. Prerequisites described by teachers included GPA minimums and course-level thresholds (i.e., former standard and honors level students needed a teacher recommendation to enroll in an AP course, former GT [gifted and talented] students did not). For example, Teacher C explained that "years ago there were GPA requirements, no more." Similarly, referring to their current AP course, Teacher B noted that "if any student wants to take it, they could." The principals offered broad perspectives of the barriers and logistics of increased access:

> Because they were not in a GT class, they may not have the same level of access to the program. What we're finding is that eighth to ninth grade year is really an opportunity where we can identify some students who perhaps are going to be really pleased in that pipeline (Principal F).

Principal G offered a similar perspective of limited opportunities for students to advance from their current academic track:

> There are *not* a lot of entry points that you tend to see through elementary and middle school. So, we really tried to kind of have a mindset of opening doors for kids who want to self-select in or getting a recommendation from the teacher.

Collectively, AP teachers and principals discussed various mechanisms, such as eliminating GPA requirements, prior course level requirements, and targeting entry points for students to advance academic tracks, have helped to open access to AP courses for students. This open access code has dovetailed well with the student recruitment code to increase AP enrollment. Still, four minor codes remain within the efforts to increase enrollment theme.

Several participants described the role of *lower-level classes* (i.e., standard and honors level courses, as opposed to the GT advanced academic track), the third code, in increasing AP enrollment. AP teachers explained that if increased numbers of students were expected in AP courses, the schools needed to extend their AP student pool beyond the GT academic track, as GT students typically matriculate in AP classes later in high school. For example, Teacher C explained how the AP teachers in their school "branched out to the standard teachers to get students who typically wouldn't sign up for an AP course, and try to get them up to speed so they're not super unprepared." Similarly, Principal F described the role of lower-level classes in increasing AP enrollment from their administrative perspective: "We try to find students in lower-level classes who can be on an AP trajectory, regardless of their placement." AP teachers and principals have reached out to lower-level classes in efforts to bolster AP enrollment, which may be related to students' differential preparation for AP courses mentioned earlier, as indicated by Teacher E:

> We have the opt in program, so you could have never had a GT English class, and you can select AP. Which again sounds great, inclusive, we're all for that, but again there is that gap [in prior knowledge] there.

Teacher E touches on an a priori code, *prior knowledge*, that will be discussed in greater detail later, and indicates their school eagerly promotes equity and bringing students from lower-level classes to AP classes, while also being aware of potential differences in students' prior knowledge that accompany such efforts.

While discussing factors related to increasing AP enrollment, several participants described a fourth code, *college admissions*. Teachers and principals described how the changes in the college admissions process in recent decades has influenced the number of students enrolling in AP courses. Teacher E pointed out that there is “a certain group of students [who] are choosing more AP classes, taking 4 or 5 AP, and that workload may contribute to a lack of success,” which brings up a theme discussed in greater detail later. Teacher E’s point that college admissions processes may have become increasingly challenging and demanding on students is echoed by Principal F, who describes many students enroll in several AP courses each year as they are “jockeying for position in class rank.” Extending this perspective, Principal F added that “a little over ten years ago, the College Board, really pushing into the system and pushing into the classroom [*sic*], and AP courses became so much more of a higher stakes thing for college acceptance.” Although most participants described college admissions processes as playing a role in increasing AP enrollment, Principal G offered a counter point: “[There is] competition between [college] credit that the student could possibly get through [the community college]; they can matriculate, you know, into post-secondary as well.” Dual-enrollment in community college offers an alternative way for high school students to earn college credits, and dual-enrollment may dampen increases in AP enrollment. Nonetheless, the competitive college admissions process may be positively influencing AP enrollment.

A final code that emerged within the theme of increased AP enrollment is *unintended consequences*. Participants were supportive of increases in AP enrollment; however, most described undesirable consequences of increased AP enrollment. Principal F addressed a particular unintended consequence: “The academic profile of AP courses has shifted, that’s what we want to do…we want to shift all kids up a level. But we encountered problems [when] not everyone starts from the same spot.” Teacher B confirmed the results of a similar unintended consequence: “It's been very few times where I would say somebody in like a standard track has gone up to an AP track and been successful." This teacher indicated an unintended consequence of increased AP enrollment, and pointed to a need to better support AP students and teachers, particularly those students who do not have an advanced academic background. Principal F brought up an unintended consequence of increased AP enrollment from a broader school resources perspective:

> I had AP classes of 4 kids…that was unintended consequences of increasing enrollment…that was something very difficult to maintain...with our resources continuing to dwindle, regardless of access, seven kids in the class or not, is not sometimes the wisest use of resources.

This principal explained that although increasing AP enrollment generally had positive effects for students and the school, being required to increase AP enrollment quickly, without adequate human, time, and financial resources, led to negative unintended consequences, such as reduced funding for other areas. In conclusion, five issues emerged from the data which have positively influenced AP enrollment: student recruitment, open access, lower-level classes, college admissions, and unintended consequences.

AP exam pass rates. All participants discussed AP exam pass rates as a measure of student success in AP classes. The two codes that emerged within this theme are *minimal emphasis* on AP exam pass rates and a prevalent *access misconception* regarding AP courses.

Schools generally placed less importance on AP exam pass rates compared to schools' emphasis on increasing AP enrollment, leading to the code, *minimal emphasis* on AP exam pass rates. When discussing the importance of AP exam pass rates for their students, AP teachers often described that there is "no pressure from administration" (Teacher B) on teachers to have their students perform well on the AP exam. This sentiment was reinforced by Principal F, who stated that "AP exam scores is *not* my priority." Similarly, Teacher A pointed out that their school places minimal emphasis on AP exam pass rates, and instead, "Over the years, it's always been just about the enrollment numbers." Additionally, Teacher C noted that "The best administrator I ever worked for said, yes, I know the score is important, but I also know the experience of taking the exam is valuable for our students." The only participant who expressed any emphasis at all from administrators on AP exam pass rates was Teacher E, who explained that "The school wants the enrollment numbers, so we get high marks in that, but they also want the pass rate. It's not like there is a punitive side to it, but there is a judgement." Overall, most participants minimized the importance of students earning passing scores on the AP exam, and rather, described an emphasis on increasing AP enrollment, even at the potential detriment of AP exam scores. This notion of valuing AP enrollment over AP success underpins the second code that emerged, the *access misconception* regarding AP courses.

According to the majority of related literature, tangible benefits of AP courses are conferred only to students who are successful in AP courses, which can be demonstrated by passing the AP exam, but students who merely enroll in AP courses but do not pass AP exams do not reap most of the potential AP benefits (Ackerman et al., 2013; Evans, 2019; McKillip & Rawls, 2013; Morgan & Klaric, 2007; Smith et al., 2017). However, there is a consensus among AP teachers and principals that merely exposing students to AP courses will result in academic benefits for those students, leading to the code, *access misconception* regarding AP courses. Both principals interviewed expressed this misconception; Principal F described "For us, it really is an exposure to that rigor and to that type of thing." Similarly, Principal G explained that "Our philosophy is really about the experience of the AP class." AP teachers agreed: "Access to that kind of curriculum has had a positive effect on the overall achievement of those kids" (Teacher E), and "While they might not be like, A or B students, you know, they will benefit from taking a more rigorous, and in [*sic*] college level class to prepare them for college" (Teacher A). AP teachers and principals clearly value increasing access to and enrollment in AP courses over students demonstrating success in AP courses. While increasing access to AP courses is important, the belief expressed by AP teachers and principals that mere exposure to AP courses will better prepare students for the future is not supported in the literature. Thus, there is a need to address this misconception in schools and provide the supports needed for AP students and teachers to be better equipped to achieve success in AP courses.

Differences in students' prior knowledge. All participants described differences in students' prior knowledge as a factor influencing the success of AP students. Within this a priori theme of prior knowledge, several codes emerged: *varying skill levels*, *varying academic experiences*, *teachers' mindset (regarding differences in students' prior knowledge)*, *test-taking strategies*, *teaching early grade levels*, and *studying strategies*.

Most AP teachers described their AP classes as having more diverse academic profiles now than in the past. AP teachers generally attributed this to increasing numbers of students entering their AP classes with *varying skill levels* (i.e., the diverse range of academic skills demonstrated by AP students). Teacher A described this phenomenon as: "This has kind of been the trend over the years, there's a lot of gaps in learning coming from the middle school and coming from early high school." Teacher E also spoke to the increasingly diverse academic profile in their AP courses:

> A lot of them come in with varying ability levels, which was not the more traditional AP English classroom…for instance, we tested this year…scores ranged from 14-51 (out of 55 MC) within one single class. That wasn't the case several years ago.

The specific abilities AP teachers perceived lacking in their students varied between content areas; for example, the AP Spanish teacher explained that "I didn't feel they had enough skills to be able to interpret and analyze authentic resources they were expected to know and complete on the AP exam." Although teachers often expressed varying ability levels among students as a limiting factor for student success in their AP courses, no teacher spontaneously mentioned related a priori codes: self-efficacy, self-determination, and achievement motivation. Therefore, probing questions were asked, and no participants identified any of these constructs as a critical skill for students to be successful in their AP class. For example, when asked if motivation is essential for student success in their AP class, Teacher A replied that “having motivation and drive to do a good job can help, sometimes it's not enough.” Teacher D agreed: “It’s not motivation holding them back.” Therefore, according to the participants, the constructs of self-efficacy, self-determination, and achievement motivation may be less important in student success in AP courses relative to varying ability levels of students in AP courses. These varied ability levels indicate a need for improved supports for AP students and teachers.

A related, but distinct, code emerged regarding differences in students’ prior knowledge, *varying academic experiences*, which describes the diverse educational history experienced by AP students. AP students who have differentially lower quality past academic experiences are likely to be at a disadvantage compared to their AP peers who have had the benefit for higher quality academic experiences. Teacher C summarized this limitation to success as, “They haven’t always gotten a good education that should make them ready” for AP courses. Teacher E described their AP students as having diverse academic experiences and subsequent negative consequences: “Students who are not coming from a GT background tend to struggle in my [AP] course…they weren’t taught the same skillset.” Similarly, Teacher B explained that “You do need to have, you know, certain skills in order to be successful at the exam. Because there's so many gaps and differences in what they've learned.” Teacher A offered a specific consequence of such varied academic experiences in an AP course: “Last year there were [AP] teachers who said that they couldn't teach the proper curriculum, because some of the kids were behind.” Not being able to adequately teach an AP curriculum will clearly inhibit students' success in the course and on the AP exam. Overall, AP teachers perceived the varied prior academic history of their current AP students as a detrimental to student success. This further indicates a need to support AP teachers in differentiating instruction to optimally teach all students who have varying previous academic experiences.

A third code that emerged related to the differences in student's prior knowledge theme is *teachers' mindset* with regard to how teachers perceive the increasingly diverse academic profile of AP classes. Although teachers did not contribute to this code, both principals explained how their AP teachers have shifted mindsets recently toward being inclusive and supportive of incoming AP students who lack an advanced academic background. Principal G explained that:

> My thinking may have been different several years ago, but I think our AP teachers have begun to shift from a mindset of—a student needs to come in and be prepared and have all the skills necessary—as opposed to where we are going, which is meeting the students where they are and really having a similarly responsive mindset that you would have with a non-AP class.

The same perspective was described by principal F: "Our teachers have really said, we are going to recognize those gaps and we're going to find ways to close them, as opposed to, say, a student has a gap in their learning or skill and they're therefore not appropriate for AP." The shift toward open, inclusive, supportive mindsets of AP teachers described by the principals provides optimism toward an intervention targeting enhancing support for AP students and teachers. That is, AP teachers appear to be receptive to efforts designed to improve success of their increasingly academically diverse AP students.

Considering the diverse academic backgrounds of AP students, a specific gap in prior knowledge demonstrated by some AP students is content-specific *test-taking skills*. Students with more advanced academic experiences may have more experience taking high-stakes tests (e.g., AP exams), and consequently, more test preparation from teachers than students who have limited advanced academic experiences. Teacher D summarized the importance of test-taking strategies as "You really have to teach them how to take the exam." Teacher A explained the importance of AP teachers gaining experience with the AP exam: "I'm learning with the kids so learning what works and what doesn't work and what they need to focus on more. It allowed me and my students to get better at taking the exam." Generally, AP teachers recognize that their AP students have a range of test-taking skills, and Teacher A—in the context of AP Spanish—pointed out the importance of students being able to transfer knowledge to novel situations on AP exams:

> There's not enough time in the day that I can teach them all the vocabulary that they can actually see in the exam. So, a lot of the skills that they need, is [*sic*] being able to interpret and using what they know to different applications, to be able to understand either a text and [*sic*] audio. And then of course transition that to be able to write, and then be able to speak about it.

AP teachers generally recognized the trend toward increased emphasis of knowledge transfer on AP exams, so developing that often-underdeveloped skill (Teacher D) in AP students represents an important potential mechanism to improve student success in AP courses.

Many AP teachers do not teach the corresponding lower-grade level introductory course (i.e., both English 9 and AP English 11; Teacher E). This may be a contributing factor to AP students' differences in prior knowledge; AP teachers may be optimally capable to prepare students in introductory-level courses with the knowledge and skills the students will eventually need in an AP course. Several participants described this *teaching introductory courses* code as providing an opportunity to groom students for future AP courses because the teacher has an ample understanding of what will be needed in the AP course. Teacher A explained the benefit of teaching the introductory level courses as: "So it starts right from the beginning of [*sic*] first year that I had them as a freshman or sophomores and building those skills that I knew they needed to be able to analyze text and be able to interpret audio." Teacher D described the same benefit in their AP context:

> When those students that I taught in the freshman year, come back to me as juniors and seniors like that, it's just fabulous, because first of all, I know what they know, or should know, right? Because I taught them.

In discussing this topic, Teacher B agreed: "You understand what they need for AP. You can kind of more easily identify if those students are ready for AP and what they need…what you need to get to them in terms of content knowledge and skills." In that quote, Teacher B also alluded to the notion of identifying students who are capable and prepared to advance from a lower academic track to an AP course. To extend that point, Teacher C described a mechanism to address the differences in students' prior knowledge; establish an AP pipeline: "When I teach GT Biology, the feeder to APES and AP Bio, I can create a pipeline." Principal G similarly discussed the idea of establishing an AP pipeline as a school-wide effort:

> We really tried to create an AP Program as a school, as where I think previously we've really been looking at it departmentally. So English was doing one thing, social studies may be doing another, but recently, looking at recruitment and retention as a whole school. We really tried to create what we call an AP community so students are really feeling that the part of a pipeline or part of our program really starting in the summer prior to ninth grade.

AP teachers explained that teaching the corresponding introductory course permitted teachers to prepare students for their eventual AP course. Although there appears to be benefits to students to have their AP teacher also teach their introductory level course, establishing that as a typical policy may require substantial infrastructural changes to the school and its master schedule, including major staffing changes at the school or district level.

The final code that emerged related to differences in students' prior knowledge was *study strategies*, which are skills and techniques students apply to enhancing learning, memory, and transfer. All AP teachers strongly expressed the perception that their AP students lack adequate study strategies, which substantially inhibits their potential to be successful in their AP class. Teacher B explained the most important skills for their AP students are to know "how to study and how to take notes." Teacher B further explained that "In the past two years, I've become more aware of student needs in terms of needing to learn how to study. I used to have this assumption that they knew what they were doing already, and that was incorrect." This perception was echoed by Teacher A, who explained "They don't know how to study," and Teacher C, who stated "When you say study, they don't necessarily know what that means." Responding to a question about what the most important skills for their AP students, Teacher D replied "They should figure out the best way to study;" however, the teacher did not attempt to teach his students study strategies. A reason why some AP teachers may not teach their students study strategies was indicated by Teacher E: "They need assistance with study skills, those are key to keeping the students on track. We don't have time to teach those skills…but they need that." While some AP teachers may perceive limited time resources as a restriction to teaching students study strategies, other AP teachers disagree: "I think there is time, if you can integrate those things into what you're already doing" (Teacher C). There is a clear consensus that AP teachers perceive their students as needing to improve their study strategies. Knowledge of effective study strategies could be developed in a school-based PL for AP teachers. Further, mechanisms to seamlessly incorporate effective study strategies into existing lessons could be cultivated through PL, and may provide AP teachers with a pathway to improve student success in AP courses without sacrificing substantial instructional time.

Collaboration. All AP teachers and principals discussed concepts related to opportunities for collaboration—or lack thereof—among AP teachers. Three codes emerged within this theme: *isolation*, *negative experiences*, and *vertical teaming*.

Collaboration with colleagues is a critical component of effective PL models (Darling-Hammond et al., 2017). However, participants described that AP teachers often work in *isolation*. AP courses often have only one AP teacher per content area in each high school, which may limit opportunities for content-specific collaboration. For example, as Teacher D explained: "I've been the only [AP] World History teacher at [my school] for many years." Several AP teachers described this lack of opportunities to collaborate as a hindrance: "It is isolating, I don't have anyone to bounce ideas off of" (Teacher C). In offering a suggestion as to how to improve the current "insufficient opportunities for collaboration" (Teacher B) among AP teachers, Principal F explained that "We need to better diversify our portfolio of AP teachers…need to get more teachers involved in teaching AP courses. Having more than one person, natural collaboration could exist." Although this principal's suggestion is logical, it is actionable only at relatively high levels due to the staffing and infrastructure changes that would be required. Thus, if the feasibility of having multiple AP teachers of each content at most schools is unlikely, perhaps collaboration among all AP teachers of various content areas within a school would provide a platform to enhance student preparedness and success in AP courses. The notion of a within-school AP PLC will be examined later, as participants discussed collaboration in the context of PL.

Although participants yearned for more opportunities to collaborate with AP colleagues, several participants described *negative experiences* when afforded the rare opportunity to collaborate with AP colleagues. For example, Teacher A explained: "I've had a few teachers over the years I was able to collaborate with, but [it] was never a great experience...I would love to find someone who was willing to collaborate and share." Other AP teachers had a similar experience: "I've worked with people in the past who did not want to collaborate" (Teacher E);

“My first year, there was another teacher teaching AP Environmental, but we didn’t collaborate or bond much” (Teacher C). Accordingly, simply positioning multiple AP teachers of each content in a school does not ensure effective collaboration. Achieving meaningful collaboration among AP teachers likely more nuanced, and additional considerations may be important: is the collaboration supported with effective PL, do the teachers have common planning time, and do the teacher have adequate time—aside from other responsibilities—to collaborate? Alternatively, some participants described vertical teaming as an effective collaborative model for AP teachers.

Vertical teaming is collaboration among teachers of various grade levels within a discipline, which can align content, expectations, skills, and knowledge for students as they progress through grade levels. Effective vertical teaming may help improve early grade level teachers’ understandings of the perquisites for students’ eventual AP course. Vertical teaming “Helps the middle school teachers understand what students will need once they get to AP classes in high school” (Teacher B). Although some AP teachers indicated they have not had opportunities to engage in vertical teaming, other AP teachers in the district “Have gone down to the middle school or a little bit of vertical alignment” (Teacher B). Teacher A described how their context has recently began vertical teaming: “New this year, four times a year, we are vertical teaming with all the high school and middle schools in our region.” The AP teachers who have not had opportunities to engage in vertical teaming expressed an understanding of the value of such curricular alignment: “Vertical teaming is extremely important, and it’s probably less common than grade-level teaming” (Teacher E). Principal G discussed how logistical challenges often inhibit opportunities for vertical teaming, explaining “We're lucky because we're in the same building as the middle school.” However, vertical teaming does not have to be limited to collaboration between middle and high school teachers. Perhaps just as valuable, a grade 11 AP teacher "collaborating back with that ninth-grade teacher" (Principal G) can importantly align skills, knowledge, and expectations for future AP students. Similarly, most content areas in the district follow a general progression of courses (e.g., in social studies: government in grade 9, world history in grade 10, U.S. history in grade 11); therefore, vertical teaming within a discipline in a single school may afford meaningful opportunities to established alignment as AP students' progress through high school.

Professional learning. Participants responded to questions intended to understand how AP teachers described their PL preparation for teaching an AP course. Within this theme, four codes emerged: *Advanced Placement Summer Institute (APSI)*, *Advanced Placement Teacher Community (APTC)*, *PLCs*, and *positive deviants* (i.e., AP teachers whose behaviors result in substantially better outcomes compared to similar peers).

The *APSI* was a commonly reported PL that AP teachers held in high regard. The APSI is an intensive, summer, week-long training program led by experienced experts designed for teachers new to teaching an AP course (College Board, 2018). AP teachers explained that the APSI was very valuable in helping become prepared to teach an AP course:

> I've done that summer institute...and that's great, especially as a new AP teacher, going and not only learning about the exam itself but getting a lot of resources from those who are in the class as well as the professor. The teacher provided a lot of the textbooks that are offered as samples (Teacher A).

Similarly, Teacher C explained the APSI was "so valuable…I learned so much from that. While Teacher D agrees, they also bring up an additional point:

> I don't think I could have taught the course, like I would have gone in, you know, quaking in my boots, if I hadn't taken that course...I think it might be more useful to have like, even every couple of years, an institute that like, you know, an update or brush up, here's what's new, you know, I would love to retake the institute, quite frankly.

Teacher D brings up the idea of attending the APSI periodically: If the APSI is so effective in preparing teachers to instruct AP courses, why do AP teachers not regularly participate in this

PL? Teacher D suggests an answer: “The district is pretty keen on sending you if you're a first timer, but after that, it's too expensive.” This perspective was confirmed by Principal F: “We don't have the ability to send a number of teachers to the summer institute.” Collectively, AP teachers and principals perceive the APSI as a valuable form of PL that prepares teachers for instructing an AP course. However, the APSI appears geared toward teachers new to AP, and moreover, funding does not exist to support substantial numbers of AP teachers periodically attending the APSI. Not all PL for AP teachers were described as so effective.

The *APTC* is an online resource available to all AP teachers, which provides opportunities for collaboration through online discussion boards and resource sharing. Despite the potential benefits of the APTC, participants generally described the APTC as unhelpful. AP teachers did not find the overall design of the APTC user-friendly, as described by Teacher C: “I find it cumbersome.” Teacher E explained the vast amount of information contained within the APTC is overwhelming, as they explained: “I don’t find the time to use the online forum, it's daunting.” Teacher A also felt the APTC is generally not the best use of their time: “College Board online collaboration, this is the first summer that I actually took a look at it. And some things are good, some things are not so good. It really just depends on who's posting it.” Although AP teachers desire collaboration, the APTC does not appear to satisfy that need, because none of the AP teachers reported using it effectively. Similarly, no teachers reported reading (i.e., grading) AP exams as an effective PL, perhaps because of the relatively small number of AP teachers selected to be a reader. However, Principal G explained that:

> My teachers will tell me the most valuable experience for them is grading AP exams and really seeing firsthand the quality of work that is expected on that exam and then really using that to be able to backwards map their instruction. So, we've had several instructors be able to participate in that experience, and they have found that to be incredibly valuable.

Although becoming a reader for the AP exams may be a valuable PL, it is not readily available to AP teachers or actionable, as a relatively small number of AP teachers are selected by the College Board to be readers.

PLCs were discussed previously in the context of valuable collaboration; here, how participants perceived PLCs as a form of professional learning is discussed. A PLC is a group of educators who collaborate regularly to share expertise and work to improve teaching skills and student outcomes. A PLC comprised of all AP teachers in a school may provide the framework needed for collaboration, active learning, sharing of best practices, and constructing new knowledge from the help of experts. Participants shared generally positive past experiences with PLCs, and expressed the perspective that an AP-specific PLC in their school may provide substantial benefits. Principal G explained that "Sharing of data and best practices, and just providing time, whether it's the whole school, or all social studies, or breaking it down, you know even more specifically, would be huge." Teacher B described how beneficial having an AP PLC can be: "For the first time this year, the AP science teachers have common planning time, which is amazing." However, merely providing teachers the time and space to collaborate does not equate to an effective PLC: "We have a PLC now, it's departmental, but we don't really do much. I'd much rather be able to collaborate with other AP teachers in the school" (Teacher E). Collectively, participants expressed supportive perspectives of PLCs, particularly an AP-specific PLC. An AP PLC may provide the infrastructure needed to allow for collaboration and can be combined with other PL initiatives to enhance AP teachers' capacity, ultimately better preparing students for AP courses and improving students' success in AP courses.

Positive deviants was the final code to emerge related to the professional learning theme. Positive deviants are AP teachers whose behaviors and strategies result in substantially better outcomes compared to similar peers. Due to the privacy of AP exam scores, it is typically difficult to know which AP teachers taught students who earned the highest AP exam scores. However, participants felt that how a teachers' students performed on the AP exams overall (i.e., deidentified by student) should not be secret; rather, such information may be used to advance AP teacher effectiveness and student outcomes. For example, Teacher C explained that knowledge of other teachers' students AP exam scores may "Lead to conversations…what do you do in the classroom that is leading to success? I think there is value in knowing that…there should not be shame in scores." Similarly, Teacher B described that "If we could use those people for PD and they'd be willing, then that would be great." Referencing if having knowledge of which AP teachers are positive deviants may be valuable, Principal G explained the potential value in such information, but also expressed caution in handling the data carefully:

> Absolutely. It has to be a very careful process. But like any piece of data. There is a lot to be learned from it, particularly when you really break that data down. And you can look at it year after year as well. You know, we share that as a leadership team, we all meet with each individual teacher and go over strengths and challenges. And certainly, from a school system level it would be interesting to see, you know, where is there a subject area where there's, you know, a lot of success being experienced and, you know, it's about a master teacher who can help out with a newer AP teacher. There's a large benefit to sharing that data.

Teacher E explained that boiling a positive deviant AP teacher down to one number (i.e., students' AP exam scores) is complicated: "It could be valuable if you take into account all the variables, which is hard to do." Collectively, participants felt no need for secrecy about sharing their students' overall AP exam scores with others, and in fact, perceived benefits for themselves and their students in understanding which teachers may be positive deviants. Positive deviant AP teachers may have much to offer toward improving AP teacher capacity and AP student outcomes, as has been demonstrated by positive deviants in other fields (e.g. medicine; Bryk, Gomez, Grunow, & LeMahieu, 2015).

Instructional strategies. Participants responded to questions intended to understand what instructional actions teachers have taken to address student success in AP courses. Within this theme, two codes emerged: inquiry-based learning and summer boot camp.

Several AP teachers discussed the role of *inquiry-based learning* in AP instruction. Inquiry-based learning is a form of student-centered, active learning in which students often pose questions, solve problems, and construct their own learning (e.g., project-based lessons and flipped lessons). Some participants described employing inquiry-based instruction periodically while teaching AP courses; however, AP teachers expressed various concerns over using inquiry-based lessons regularly. For example, "I know I should use more student-centered lessons and less lecture, but I don't know how to create those kinds of lessons given my time constraints" (Teacher B). Similarly, Teacher C explained that "Some [AP teachers] use flipped lessons, but I haven't taken that leap yet." Teacher E explained how AP teachers in a different department in their school has struggled implementing project-based lessons: "The social studies department has shifted their AP courses toward project-based activities, it's been challenging for them to adjust, teachers and students, really." Collectively, while AP teachers perceived value in employing inquiry-based lessons, they also expressed reservations in employing such lessons. Reasons for these reservations included limited time resources to develop, limited instructional time to deliver, and apparent low self-efficacy to deliver inquiry-based lessons.

The second code to emerge relative to the instructional strategies theme was *summer boot camp*, which refers to summer training programs designed to prepare incoming AP students for the rigorous coursework and expectations of their upcoming AP course. Some participants explained that their school offered optional summer boot camps and reported positive results from those interventions. However, the summer boot camps were only one week long, so did not offer continued support for AP students. The content delivered in the summer boot camps was primarily to establish a level of expectations for AP courses, as Principal F described:

> We offer a bridge program in the summer, where basically, it's an exposure to different strategies to help manage, things like organization, like note-taking. Like before maybe getting a jump on the actual curriculum, it's really just kind of teaching and kind of exposing the rigor of what needs to happen in order to be successful.

Teacher C discussed some specific content covered in their school's summer boot camp: "We've tried a summer program for a week while expanding AP enrollment. Worked together to generate some organization skills, team building, content activities, to help kids who have stepped up to take the class feel more comfortable and confident." Principal G offered how adding former AP students to the summer boot camp may add value:

> So, we did a prep and AP boot camp over the summer with some of those students [new to advanced coursework] and then some of our students who took AP courses previously, who could return and provide them with additional support they may need going into the next school year.

Collectively, participants perceived value to the week-long summer boot camps to help prepare incoming AP students. However, the value of the summer boot camps may not have been optimized for several reasons, the summer boot camps: (a) did not have sustained duration, (b) did not have a way of measuring its success (e.g., "So just like mindset shift, it's really hard to quantify" (Principal G), and (c) did not include any learning or studying strategies which may be valuable to better prepare AP students and improve success in AP courses.

Summary of the Findings

This section summarizes how the key findings from this study interact with the problem of practice under investigation through the lens of the research questions. The first research question was: How has overall AP enrollment changed annually from the 2014-2015 school year to the 2016-2017 school year? The five schools analyzed varied substantially in the measures of AP program growth or decline from 2014 to 2017, including the number of students enrolled in at least one AP course, sum of AP enrollment for all classes, number of AP exams taken, and percent of students enrolled in at least one AP course. Composite analysis of all five schools' enrollment patterns indicated AP enrollment increased overall during the study period. However, data analysis was limited to only three consecutive years; therefore, the quantitative strand of the investigation was limited in fully capturing the ongoing, longer-term efforts to increase AP enrollment that began in the early 2000s.

The second research question was: How have AP exam scores changed annually from the 2014-2015 school year to the 2016-2017 school year? The five schools analyzed varied substantially in measures of AP exam success, including percent of AP exams passed and mean AP exam score. Four of the schools showed no significant change in AP exam pass rates over the study period. The fifth school's AP exam pass rate decreased significantly; it may be noteworthy that was the only school to demonstrate a decrease in AP enrollment over the three years. Collectively, there was no significant change in AP exam scores for the schools investigated, perhaps in part due to data only being available for three consecutive years.

The third research question was: What are AP teachers' and principals' perceptions of their students' ability to be successful in AP coursework? Participants acknowledged recent efforts to increase AP enrollment have been associated with an increased number of AP students from lower-level academic tracks. Accordingly, participants perceived their AP courses as having become increasingly populated with students who are differentially prepared for AP coursework. This differential preparation was largely described to be in terms of prior background knowledge and academic skills related to effective learning and studying. AP teachers and principals were supportive of open access policies and recruitment efforts that have brought increased numbers of students into AP courses, but participants also recognized a need to better support AP students, particularly those who are new to advanced academic coursework.

The fourth research question was: How do AP teachers and principals describe their professional development preparation for teaching AP courses? AP teachers described their participation in the APSI as very effective preparation for teaching an AP course. However, the APSI is expensive, so access to the program is typically limited to first year AP teachers. AP teachers described the APTC as too large, cumbersome, and overwhelming to be helpful preparation for their AP courses. However, AP teachers expressed a need for increased collaboration, but the APTC does not appear to satisfy that need. AP teachers and principals described their limited experiences with PLCs as positive and expressed a need for having PL opportunities with other AP teachers.

The fifth research question was: What instructional actions have teachers taken to address student success in AP coursework? AP teachers described employing inquiry-based instructional strategies, such as project-based lessons and flipped lessons. However, AP teachers also expressed concerns related to implementing such instructional actions, including limited time resources to develop such lessons and limited capacity to develop such lessons without additional training. AP teachers and principals in some schools also explained how they have recently implemented a summer boot camp for incoming AP students. Although these programs included activities to help students learn organizational strategies, develop note-taking skills, and gain exposure to the expectations and rigor of AP courses, these programs did not include any learning or studying strategies, which may be beneficial for improving AP student preparedness and success.

The sixth research question was: To what degree are AP teachers in different content areas similarly prepared to provide effective instruction for success in AP courses? Across the AP content areas represented by interviewees, AP teachers did not perceive their background content knowledge or general pedagogical knowledge as limiting their ability to effectively instruct AP course. Rather, AP teachers spoke to limited opportunities to collaborate with other AP teachers and restricted access to knowing who the positive deviant AP teachers are as barriers to providing effective instruction in their AP course. Additional challenges teachers described included the increasingly diverse range of prior knowledge of AP students and a general lack of adequate study strategies exhibited by their AP students.

Limitations

Some factors that may interact with the problem of practice were not able to be investigated in this study, thereby limiting the scope of the study. Such factors include macrosystem factors of the benefits of AP courses, equitable access to AP courses, and success in AP courses for students in different student demographics. Exosystem factors not thoroughly evaluated in this study include federal and state policies aimed at increasing equitable access to AP courses for all students. Certain mesosystem factors that may interact with the problem of practice were not addressed in this study, including certain school infrastructure characteristics, such as school size, class size, and teachers' course assignments. The microsystem factor of influences of family and peers on AP students may be important to the problem of practice but was not analyzed in this study.

Quantitative analysis of the five high schools' AP enrollment and AP exam scores was limited because that data were available for only three consecutive years; therefore, describing trends over time in AP enrollment and AP exam scores in the context under study was substantially limited. Additionally, the AP enrollment data for the context under investigation was based on the number of students who enrolled in AP courses, which is not necessarily congruent with the AP enrollment data maintained by the College Board, which specifies the number of students who take AP exams each year, not the number of students who enroll in AP courses. Therefore, generalizability of the data may be limited to the incongruence between global AP enrollment data described by the College Board and contextual AP enrollment data. Finally, due to the deductive nature of the quantitative strand of this study, implicit bias may exist in terms of the initial determination of the data selected to be analyzed.

Semi-structured interviews were limited to seven participants from a large district containing 24 high schools with AP Programs. Therefore, the perceptions of the seven participants may not necessarily be indicative of most of the teachers and school administrators in the district, perhaps limiting the transferability of this study to the entire district. Further, the district under study exists in a state with diverse, county-wide school districts (see Table 6), so the results may not be generalizable to other counties within the state or other areas. The insight gained into teacher and administrator perspectives were self-reported, posing a potential threat to the credibility of the study. However, the use of member checking during the interviews and peer scrutiny and reflective commentary during data analysis were intended to mitigate threats to credibility (Guba, 1981). Additionally, in attempts to achieve dependability of the qualitative strand of this study, the researcher was consistently reflective and established an audit trail by specifying details of the methodology and analysis (Guba, 1981). Similarly, in attempts to achieve confirmability of the study, any threats to neutrality were made explicit (Miles, Huberman, & Saldaña, 2014).

Chapter 3: Intervention Literature Review

This chapter will first summarize the key findings from the needs assessment that were used to determine the intervention literature to investigate. Then, sociocultural learning theory (Vygotsky, 1978) will be presented as a useful theoretical framework to guide the intervention literature synthesis. Next, the specific part of the conceptual framework of factors influencing outcomes for AP students will be identified as most likely actionable for an intervention. The core of this chapter will follow—a synthesis of best practices in professional learning (PL) that will be useful to inform a PL-focused intervention, followed by three areas of intervention literature: professional learning communities (PLCs), project-based lessons (PBLs), and retrieval practice strategies informed by science of learning (SoL) research. Finally, a summary of the intervention literature and an overview of the proposed solution will be presented.

The problem of practice is Advanced Placement (AP) expansion has been associated with a broadening AP recruitment pool that includes students without experience in advanced academic courses, leading to many students facing possible disadvantages when they pursue AP courses (Kolluri, 2018) and leading to decreasing AP exam pass rates (Judson & Hobson, 2015). AP expansion efforts since the 1990s have successfully increased access to and participation in AP courses, thereby extending rigorous, college-preparatory curricula and instruction to many more students (College Board, 2014; Judson & Hobson, 2015; Parker et al., 2013; Rowland & Shircliffe, 2016). However, whereas AP teachers and principals believe exposure to AP courses better prepares students for college, documented studies demonstrate that students who merely participate in AP courses but are unsuccessful on AP exams are not conferred the same academic and non-academic benefits as their AP exam passing peers (Ackerman et al., 2013; Evans, 2019; McKillip & Rawls, 2013; Morgan & Klaric, 2007; Smith et al., 2017). The needs assessment also indicated that AP expansion has led to rapid recruitment of teachers to instruct newly formed AP courses, and improved supports are needed for these novice AP teachers to facilitate student learning and success in AP courses.

The needs assessment presented in Chapter 2 revealed quantitative evidence that AP enrollment increased in the district under study from 2014 to 2017. Further, interview participants described substantial efforts by the district and schools to actively recruit more students into the AP program, specifically by targeting students from intermediate level classes to enroll in AP courses. Qualitative findings indicated these efforts to increase AP enrollment were based on the assumption that exposure to rigorous, college level AP courses will translate into improved outcomes for students who take AP courses; however, that assumption is inconsistent with the literature, in which there is a general consensus that benefits of AP courses are largely only available to AP exam-passers (Ackerman et al., 2013; Evans, 2019; McKillip & Rawls, 2013; Morgan & Klaric, 2007; Smith et al., 2017).

Qualitative findings from the needs assessment presented in Chapter 2 also indicated teachers perceived their current AP students were less prepared for rigorous academic work than their students were approximately a decade ago, reportedly due to their AP courses' shifting academic profile resulting from AP expansion efforts and the lack of prior experiences that would prepare students for this level course. Further, teachers and administrators believed all students—including those recruited from intermediate classes—could be successful in AP courses and on AP exams, but that they need more sustained supports before or during AP courses to meet those goals. Although many schools reported efforts to better support AP students in recent years, those supports have fallen short of being successful for all students. These supports have included strategies for writing, note-taking, and organization, as well as efforts to shift students toward a growth mindset (Dweck, 2006). None of the participating schools reported using learning, studying, or SoL strategies (e.g., retrieval practice) to help better support students in AP courses and on AP exams. Teachers perceived that AP students need increased support in learning and studying strategies—as one teacher stated, “they don’t know how to study”—which describes a potential area to be explored further in the intervention literature.

Qualitative findings from the needs assessment presented in Chapter 2 also indicated that despite teachers’ reported efforts to increase student-centered lessons, some AP teachers still relied on teacher-centered lessons (e.g., lecture) to deliver instruction, in part due to a reported self-perception of limited capacity to incorporate more student-centered lessons. Inquiry-based lessons, such as PBL, have been shown to positively influence AP student outcomes (Fischer, Eisenkraft, Fishman, Hubner, & Lawrenz, 2018a; Parker et al., 2013; Parker, 2018; Parker & Lo, 2016). Therefore, infusing more innovative, student-centered pedagogical approaches (e.g., PBL, flipped lessons, inquiry-based lessons) could enhance AP instructional methods.

Qualitative findings from the needs assessment presented in Chapter 2 also indicated that the teachers described the most helpful professional learning for enhancing AP teachers’ instruction was College Board-sponsored AP summer institutes. AP summer institutes are designed for teachers new to teaching an AP course; therefore, the summer institutes are not funded for experienced AP teachers to attend in the district under study, which may leave veteran AP teachers without substantial, sustained PL moving forward. Similarly, although teachers and administrators described collaboration between AP teachers as important for teacher capacity, teachers described their opportunities for meaningful collaboration with AP colleagues as insufficient, indicating PLCs may be a potential mechanism to enhance AP teachers' capacity to instruct AP courses.

Theoretical Framework

Sociocultural learning theory (Vygotsky, 1978) is a useful framework to organize the components of any PL intervention for AP teachers. Sociocultural theory contends that learning and behavior develop from social factors including interactions with others (Vygotsky, 1978). A key aspect of sociocultural theory includes learners' zone of proximal development, which considers where individual learners are in their development, what they can learn next on their own, and what they need help to learn (Vygotsky, 1978). Maintaining a focus on the environment, use of language, and learning with the support of others, Vygotsky's sociocultural theory is useful to design PL for AP teachers that may include effective learning and studying strategies as a mechanism to improve teachers' capacity to better prepare and support AP students for success.

Raphael, Vasquez, Fortune, Gavelek, and Au (2014) propose five principles that PL designs should incorporate to align with the emphasis on learning through social interactions in Vygotsky's (1978) sociocultural theory. First, teachers must be engaged in shared ownership over the PL design and analysis of results, thereby contributing to teacher agency (i.e., teachers' capacity to effectively direct their own professional growth and that of their colleagues). Second, PL should be situated in teachers' context and be able to address meaningful problems in teachers' context. Third, dialogical practice should be employed to provide teachers with opportunities to engage in meaningful conversations, which can further develop teachers' responsibility and agency. Fourth, PL should be systemic, so all stakeholders share an understanding of the goals and intended outcomes of the PL. Finally, PL should be sustained over time to most likely positively influence teacher capacity. Raphael and colleagues helpfully operationalize Vygotsky's theory of learning through social interactions, which can be drawn upon to design PL that positively affects AP teacher practice.

The conceptual framework presented in Chapter 1 (Figure 1.3) is modified in Figure 3.1 to indicate a possible location of intervention to address the problem of practice. The two-way relationship between teacher background and teacher practices may represent an actionable point of intervention. According to the networked ecological systems theory (Neal & Neal, 2013), teacher background is influenced by many factors, including PL, which exists at AP students' exosystem (i.e., interactions do not directly involve the focal individual, but the results of interactions at this level affect the focal individual directly or indirectly. AP teacher practices exist within an AP students' microsystem (i.e., interactions occur between focal individual and their immediate environment; Neal & Neal, 2013), as AP students interact with their AP teachers' instructional practices in every class. The areas of intervention literature review discussed next all act at the potential point of intervention represented by the double-arrow between teacher background and teacher practices. This pivotal placement of the intervention can enhance AP teacher capacity to positively influence student success in AP exams and AP courses.

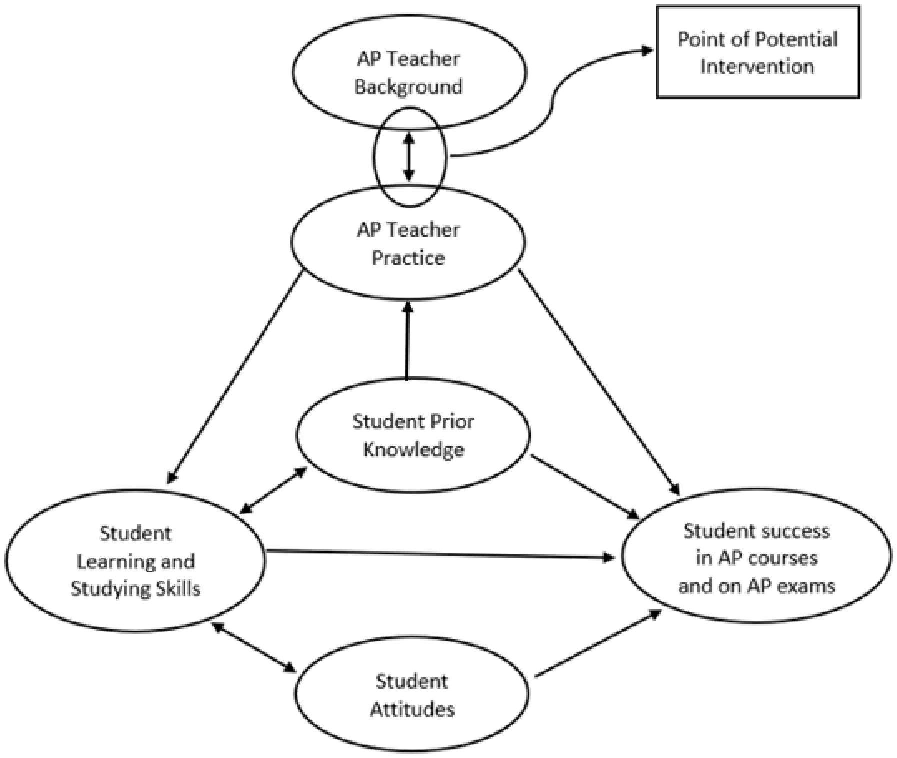

Figure 3.1. Potential point of intervention within the conceptual framework of factors influencing student success in AP courses and on AP exams

Intervention Literature Synthesis

This section will first discuss a synthesis of effective PL based on Darling-Hammond, Hyler, and Gardner's (2017) conceptual framework. Then, a synthesis of intervention literature from three fields will be presented: professional learning community (PLC) interventions, project-based learning (PBL) interventions, and retrieval practice interventions. These three fields of intervention literature were selected for investigation based on key findings from the needs assessment that align with the problem of practice and present a practical point of intervention in the professional context under investigation.

Professional Learning Framework

The link between effective teacher PL and improvements in student learning outcomes is well established in the literature (Darling-Hammond et al., 2017; Desimone & Garet, 2015; Swan

Dagen & Bean, 2014), and high-performing academic systems emphasize teacher PL as the driver of improving student learning (Jensen, Sonnemann, Roberts-Hull, & Hunter, 2016). Darling-Hammond and colleague's (2017) conceptual framework for effective PL is useful to design an intervention that aims to enhance AP teachers' practices. Darling-Hammond and colleagues explain effective PL results in positive changes in teacher practices and increases in student learning outcomes when the PL includes seven characteristics: (a) focuses on content, (b) infuses active learning based on adult learning theory, (c) includes situated opportunities for collaboration, (d) incorporates models of effective practice, (e) uses coaching or support of experts, (f) provides opportunities for reflection and feedback, and (g) is maintained for a sustained duration. Each of these characteristics and literature reviewed is displayed in Table 3.1 and is described below.

Table 3.1

Professional Learning Literature Reviewed

Topic	Sources
Frameworks for best practices in professional learning	Darling-Hammond et al., 2017; Desimone & Garet, 2015; Jensen et al., 2016; Learning Forward, 2011
PL should be content focused	Fisher & Frey, 2014
PL should involve active learning	Jacobs & Yendol-Hoppey, 2014; Raphael et al., 2014; Rohlwing & Spelman, 2014; Swan Dagen & Bean, 2014; Youngs & Lane, 2014
PL should be situated and collaborative	Calvert, 2016; Raphael et al., 2014
PL should model effective practice	Tschannen-Moran & Chen, 2014
PL should include coaching and expert support	Avalos, 2011; Youngs & Lane, 2014
PL should include opportunities for feedback and reflection	Calvert, 2016; Fisher & Frey, 2014; Guskey, 2014; Jensen et al., 2016; Raphael et al., 2014
PL should be of sustained duration	Calvert, 2016; Fisher & Frey, 2014; Jensen et al., 2016; Raphael et al., 2014

Content focused. Professional learning that positively influences student learning focuses on the specific content that teachers instruct (Darling-Hammond et al., 2017). This content-focused PL should be situated in teachers' contexts and aligned with system priorities to provide coherence across the PL opportunities offered over time for teachers (Darling-Hammond et al., 2017). This design enables teachers to build on what they already know, aligns with educator performance standards, and supports ongoing PL with educators in similar contexts (Learning Forward, 2011). Professional learning that is content focused, coherent, and differentiated can align with sociocultural approaches described by Vygotsky (1978) by existing in each teacher's zone of proximal development and utilizing the language and signature concepts of specific content areas.

Changing teachers' procedures or classroom behavior is more immediately possible for teachers than improving content knowledge or inquiry-based practices (Desimone & Garet, 2015). Therefore, PL that is content focused must not necessarily teach educators content knowledge, but it should still focus on the content teachers instruct, and PL design should allow for variation in teachers' response to the PL based on their prior experience and background content knowledge (Desimone & Garet, 2015). Fisher and Frey (2014) suggest that PL designs in high school settings should be customizable to meet the needs of each teacher; for example, PL in high schools can be differentiated by teaching some teachers content knowledge background, other teachers general pedagogical strategies, and other teachers pedagogical content knowledge (see Shulman, 1986). In addition to PL being content-focused, Darling-Hammond and colleagues (2017) identify a need for active learning as the second characteristic of effective PL.

Active learning. Effective PL for teachers should provide opportunities for active learning and be consistent with adult learning models (Darling-Hammond et al., 2017; Swan Dagen & Bean, 2014). Active learning in PL directly engages teachers in practices they are learning and provides relevant connections to teachers' classrooms and students (Darling-Hammond et al., 2017). Adult learning models recognize: (a) adults enter PL with backgrounds that should be perceived as resources, (b) adults should be empowered to choose learning activities that support their needs, and (c) inquiry and reflection should be key components of PL activities (Darling-Hammond et al., 2017). Aligned with adult learning theory, teachers need to know why they need to know something, so PL should provide teachers with a clear purpose and rationale for the PL (Rohlwing & Spelman, 2014). Implementation of PL that aligns with adult learning models often incorporates teacher experience, reflection, context, and dialogue (Rohlwing & Spelman, 2014). Teachers engaging in dialogue follows recommendations from sociocultural perspectives as teachers can learn from their environment and discussions with other teachers (Raphael et al., 2014). Discussing how to employ new instructional practices is most meaningful when the dialogue is situated and connected to problems of practice relevant to teachers' contexts (Raphael et al., 2014).

Effective PL should be designed to promote teachers' active engagement in their context, collaboration, discussion, problem-solving, reflection, and inquiry (Learning Forward, 2011). Professional learning that involves sustained inquiry may provide opportunities to: (a) examine student thinking and learning, (b) measure student understanding using pre-tests and formative assessments, (c) teach experimentally, or (d) use knowledge and feedback from students to modify practice (Youngs & Lane, 2014). Mechanisms to engage teachers in analyzing and learning from their own practice over time include techniques such as lesson study, action research, cognitively guided instruction, and instructional coaching (Youngs & Lane, 2014). Incorporating action research in PL offers various benefits, including prioritizing the needs of teachers, supporting teacher agency over their own PL, encouraging schoolwide PL, and cultivating inquiry (Jacobs & Yendol-Hoppey, 2014). As well as providing opportunities for active learning, effective PL should incorporate collaborative activities for teachers (Darling-Hammond et al., 2017).

Situated collaboration. Collaboration among teachers has become a focal point of high-quality PL (Darling-Hammond et al., 2017; Desimone & Garet, 2015). Engaging teachers in collaboration that is situated in their context allows opportunities to positively affect teachers' instruction and the school culture (Darling-Hammond et al., 2017). Situated collaboration promotes continual dialogue and establishing learning communities enables teachers to share what they have learned with each other, aligning with sociocultural approaches to PL (Raphael et al., 2014).

Situating PL in teachers' contexts positions teachers to be agents of change (Raphael et al., 2014). Teacher agency can be promoted through collaborative PL interventions by establishing shared responsibility through peer networks that are interpretive and analytical but non-evaluative (Calvert, 2016). Calvert describes seven steps school leaders should consider to improve teacher agency: (a) consult teachers about PL choices, (b) create a master schedule that permits time for regular collaboration, (c) involve teachers in needs assessments and data analyses, (d) establish learning communities, (e) provide teachers choice and autonomy in directing their own PL, (f) design PL for the purpose of growth instead of evaluation, and (g) resist the urge to scale up PL too soon. Increased teacher agency may create additional opportunities for teachers (Darling-Hammond et al., 2017), as teachers may take on additional leadership functions and act as instructional leaders (Swan Dagen & Bean, 2014). Teachers in leadership roles should help design and lead PL, which helps school and district goals align better with teacher needs (Jensen et al., 2016); those teacher needs should determine the PL design and content delivered (Learning Forward, 2011). Darling-Hammond and colleagues' fourth characteristic of effective PL is incorporating models of effective practice.

Modeling effective practice. Effective PL often includes modeling instructional or curricular best practices to establish a shared understanding of high-quality teaching practices (Darling-Hammond et al., 2017). Modeling applications may manifest as teachers viewing or interacting with models such as lesson plans, pedagogical case studies, video-recorded lessons, student work samples, or curricular materials (Darling-Hammond et al., 2017), or as co-teaching, coaching, problem-based learning, action research, or applying inquiry to practice (Learning Forward, 2011). The emphasis on learning from interactions with peers and specialists that occurs through using models of effective practice align with Vygotsky's (1978) sociocultural theory. Further, PL that features effective models may support building teachers' self- and collective-efficacy (i.e., learning highly effective practices through modeling may influence teachers' motivation and capability to implement new instructional strategies or PL goals; Tschannen-Moran & Chen, 2014). Examples of modeling effective practice, coaching and expert support, are key characteristics of effective PL (Darling-Hammond et al., 2017).

Coaching and expert support. Sustained engagement in mentoring, coaching, and using the support of experts can support effective implementation of PL (Darling-Hammond et al., 2017). Although coaching can represent a component of the modeling effective practice characteristic of effective PL, Darling-Hammond and colleagues (2017) identify coaching as a separate characteristic because of its pervasiveness in effective PL and its capacity to scaffold support for teachers when focusing on teacher needs and sharing best practices. PL designs that promote coaching can be one-on-one or large group collaborations (Learning Forward, 2011). Accessing expert support may extend to human resources beyond the school (Darling-Hammond et al., 2017) which may include district administrators and other outside experts who promote teacher agency, collaboration, inquiry, and teacher research skills (Youngs & Lane, 2014). Learning through the help of coaches or other experts dovetails with Vygotsky's (1978) explanation of how learning occurs in a person's zone of proximal development.

State, district, and school leadership play a key role in ensuring educators can reap the benefits of coaches and other experts (Learning Forward, 2011). Leaders need to allocate the requisite human resources (e.g., coaches and experts), technology, and curricular resources to optimally implement the best practices suggested by coaches and experts (Learning Forward, 2011). Similarly, leadership should be supportive in enabling teachers to access effective PL resources, including coaches (Avalos, 2011). District and school leaders should create support systems for PL and develop teachers' capacity for learning and leading PL (Learning Forward, 2011) so the expertise of teachers can be tapped to help design and implement effective PL (Jensen et al., 2016). Further, school leaders should support and encourage teachers to implement strategies learned through PL (Desimone & Garet, 2015), which is connected to the feedback and reflection concepts of Darling-Hammond and colleagues' (2017) sixth characteristic of effective PL.

Feedback and reflection. Teachers need time to think about their own practice and opportunities to receive feedback on their own practice (Darling-Hammond et al., 2017). Teachers and schools should be mindful that reflection and feedback can drive cycles of continuous improvement (Learning Forward, 2011). Providing teachers with feedback and opportunities for reflection demonstrates a responsiveness to teacher needs (Darling-Hammond et al., 2017) and may inform future PL based on teacher needs (Desimone & Garet, 2015). A source to provide reflection is analyzing student work as evidence for misconceptions, effectiveness of instructional practices, and examples of high- and low-quality student work (Darling-Hammond et al., 2017). Vygotsky's (1978) sociocultural theory is reflected in the feedback from peers and school leaders that teachers receive as they learn with the help of others. Further aligning with sociocultural approaches to PL, achieving desired outcomes can be supported through backward design based upon reflection (Raphael et al., 2014). Reflection on practice and feedback from others may interact with three topics described in this section: (a) theories of teacher change, (b) evaluation of PL, and (c) student learning objectives.

Teacher change. Studies investigating teacher change identify reflection and feedback as critical features of professional learning (Learning Forward, 2011), which theorists explain as driven by reflection and feedback (Clarke & Hollingsworth, 2002; Guskey, 2002). Guskey's (2002) model of teacher change stipulates that changes in teachers' beliefs come only after teachers observe changes in student learning outcomes resulting from implementation of new practices. Therefore, Guskey's model espouses that teacher change occurs in a series of stages; PL impacts changes in teachers' classroom practices, which in turn positively affects student learning outcomes, which then changes teachers' beliefs and attitudes. Contrastingly, the interconnected model of professional growth proposed by Clarke and Hollingsworth (2002) presents a more dynamic perspective of how teacher change occurs as a result of a series of enactment and reflection that occurs among four domains in a teacher's environment: PL; implementation of practices; outcomes of practices; and a teacher's personal knowledge, beliefs, and attitudes. Both models of teacher change acknowledge the important role reflection and feedback play in leading to salient teacher change (Clarke & Hollingsworth, 2002; Guskey, 2002).

Evaluation of PL. Evaluation of PL is critical for continual improvement (Learning Forward, 2011). The standards for professional learning recommend using a variety of sources (e.g., student, teacher, administrator, and family) and types of data to plan, assess, and evaluate PL over time (Learning Forward, 2011). PL evaluation should use a variety of data from all stakeholders to complement student achievement data (Jensen et al., 2016). Regular evaluation of PL allows for identification of staff needs (Calvert, 2016; Darling-Hammond et al., 2017), which can be conducted using staff surveys that can help ensure PL is connected to practice (Darling-Hammond et al., 2017). Professional learning evaluation that includes needs assessments should lead to targeted PL that can be differentiated in content and processes (Fisher & Frey, 2014). Guskey (2014) outlines five levels of PL evaluation that are helpful to set up PL for continuous improvement: (a) participants' reactions, (b) participants' learning, (c) organizational support and change, (d) participants' implementation of knowledge or skills, and (e) student learning outcomes. Regarding level four, implementation should be measured because a lack of fidelity to implementation may render PL efforts ineffective (Desimone & Hill, 2017). It may be important to consider PL that requires teachers to make larger changes may be associated with higher fidelity of implementation (Anderson, 2017). Regarding level five, a critical component of PL evaluation includes reflection and feedback on student learning outcomes (Learning Forward, 2011).

Student learning outcomes. Teacher reflection and feedback from colleagues can link educator performance standards with student learning outcomes (Learning Forward, 2011). Professional learning that is systemic (i.e., focuses on the same goals for all stakeholders) can support improvements in student learning outcomes (Raphael et al., 2014). Maintaining a focus on student learning outcomes can positively enhance educator responsibility (Learning Forward, 2011). A source of reflection and feedback may include analyzing student work to inform instruction and improve student learning outcomes (Darling-Hammond et al., 2017); therefore, secondary school PL should include time for teachers to analyze student work samples to reflect on what efforts are working well (Fisher & Frey, 2014). Darling-Hammond and colleagues' final characteristic of effective PL is to maintain sustained duration.

Sustained duration. Successful PL must be sustained over time (Darling-Hammond et al., 2017; Desimone & Garet, 2015; Fisher & Frey, 2014; Learning Forward, 2011; Raphael et al., 2014), providing teachers adequate time to learn, practice, implement, and reflect upon new strategies implemented in their practice (Darling-Hammond et al., 2017). Professional learning that is sustained for an adequately long duration has the potential to add perceived value to PL and positively alter the school culture (Darling-Hammond et al., 2017). School leadership must sustain support for implementation of the PL over time (Learning Forward, 2011), which may incorporate teachers' engagement in collaboration, mentoring, coaching, or other forms of PL (Darling-Hammond et al., 2017). Professional learning that is sustained over time provides teachers with opportunities to engage with each other about content knowledge and pedagogical practices that can strengthen the functionality of collective work groups (Raphael et al., 2014). These high-functioning, sustained work groups align with Vygotsky's (1978) sociocultural theory as teachers engage in learning from each other in their zones of proximal development.

Schools should be cautious of potential barriers of successfully sustaining the duration of PL (Darling-Hammond et al., 2017; Desimone & Garet, 2015). First, conflicting requirements of other school policies (e.g., curricular scripts and pacing guides) may inhibit fidelity of the implementation of PL (Darling-Hammond et al., 2017). Second, PL design may appear fragmented due to multiple PL providers—who may have differing goals—implementing PL with little overarching cumulative design (Desimone & Garet, 2015). Finally, the most well-documented potential barrier of sustained duration PL is limited time resources (Calvert, 2016; Darling-Hammond et al., 2017; Desimone & Garet, 2015; Jensen et al., 2016). Schools should evaluate and redesign school schedules to incorporate adequate time for sustained PL (Darling-Hammond et al., 2017), which should permit time for teachers to meet and regularly collaborate with colleagues (Calvert, 2016; Jensen et al., 2016) Specifically, Desimone and Garet (2015) suggest 20 or more hours of contact time throughout the school year for ongoing PL activities to provide effective learning outcomes for teachers.

Summary of Professional Learning Literature

Effective PL is critical to ultimately improve student learning outcomes (Darling-Hammond et al., 2017; Desimone & Garet, 2015; Swan Dagen & Bean, 2014). Placing PL centrally in a system's progress plan is a key component of high-performing systems (Jensen et al., 2017). PL evaluation is critical for informing continual improvement (Calvert, 2016; Learning Forward, 2011). The seven standards for professional learning (i.e., learning communities, leadership, resources, data, learning designs, implementation, and outcomes; Learning Forward, 2011) support Darling-Hammond and colleagues' (2017) conceptual framework for effective PL. Thus far, this literature review synthesized PL literature into Darling-Hammond and colleagues' conceptual framework, which consists of seven characteristics of effective PL: (a) focuses on content, (b) infuses active learning based on adult learning theory, (c) includes situated opportunities for collaboration, (d) incorporates models of effective practice, (e) uses coaching or support of experts, (f) provides opportunities for reflection and feedback, and (g) is maintained for a sustained duration. Raphael and colleagues (2014) apply Vygotsky's (1978) sociocultural learning theory, in which individuals learn primarily with the help of others through social interactions in their zone of proximal development, to teacher learning through effective PL. This review of effective PL underpins potential points of intervention for improving AP teachers' capacity to better prepare students for success in AP courses through potentially implementing: an AP professional learning community, PL designed to increase AP teachers' implementation of project-based lessons, or PL designed to increase AP teachers' implementation of retrieval practice learning and studying strategies as informed by SoL research.

Professional Learning Community Intervention Literature

PLCs provide opportunities for teachers to engage in situated collaboration through a supportive network (Darling-Hammond et al., 2017). A PLC is a group of educators available to support one another who share a vision and regularly meet to share expertise, learn with each other, and improve practices in an inquiry-driven environment (Hord, 1997). PLCs should maintain sustained duration over time, include a professional-learning leader (Darling-Hammond et al., 2017), and meet at least weekly (Jensen et al., 2016). PLCs provide a mechanism to ensure collaboration, promote continuous improvement (Learning Forward, 2011), and enhance teacher agency (Calvert, 2016; Raphael et al., 2014). A summary of the PLC literature reviewed is presented in Table 3.2.

Table 3.2

Professional Learning Community Literature Reviewed

Topic	Sources
Characteristics of effective PLCs	DuFour, 2007; Graham, 2007; Hattie, 2012; Hord, 1997; Levine, 2019
PLCs have positive influences on teachers	Gwinn & Watts-Taffe, 2017; Prenger, Poortman, & Handelzalts, 2019
PLCs have positive influences on student learning	Lomos, Hofman, & Bosker, 2011
PLCs in AP contexts	Flores & Gomez, 2011; Frumin et al., 2018

AP teachers and principals recognized the importance of regular and meaningful collaboration among AP teachers in the needs assessment presented in Chapter 2; however, AP teachers described a lack of opportunities to collaborate with AP colleagues. Thus, an AP PLC could be a potential point of intervention for improving AP teachers' capacity to better prepare students for success in AP courses. An AP PLC may afford AP teachers time and opportunity to co-plan, share best pedagogical practices, and engage in dialogue with other AP teachers about student barriers, student strengths, student supports, and AP exam preparation strategies. Practical application of an intervention involving an AP PLC would require dedicated time and physical or technological recourses for AP teachers to meet and collaborate. A review of PLC intervention literature is synthesized next.

Characteristics of effective PLCs have been described in the literature (Graham, 2007; Levine, 2019). From a review of PLC literature, Levine (2019) helpfully summarizes five suggestions to overcome typical obstacles to effective PLCs. First, PLCs should promote coherence and follow-though, instead of being episodic and infrequent. Second, PLCs should incorporate outside perspectives to avoid consistently reinforcing groupthink, which can occur by always meeting with the same colleagues. Third, PLCs should ensure equal participation from all participants to create deeper, lasting learning for participants. Fourth, PLCs should develop a culture in which participants can move past congeniality and offer respectful candor. Finally, PLCs should develop participants' comfort with moving outside of the privacy and autonomy that many teachers have become accustomed to by offering frequent collaborative problem-solving opportunities in the PLC (Levine, 2019). An empirical investigation to describe characteristics of effective PLC was conducted in a southeastern middle school in the 2004-2005 school year (Graham, 2007). This mixed-methods case study used descriptive statistics of teacher surveys (n = 15) and interviews (n = 10) to describe how PLCs influenced teacher effectiveness. Teachers indicated increased levels of change in their knowledge, skills, and practice with the following characteristics of their PLC: (a) content focus, (b) active learning, and (c) coherence (Graham, 2007). These findings of effective PLCs are consistent with recommendations from effective professional learning literature (Darling-Hammond et al., 2017). Nonetheless, establishing PLCs does not automatically ensure enhanced teacher capacity nor increased student performance. Rather, the potential positive influence of PLCs is largely dependent upon educators' collective capacity, commitment, and persistence (DuFour, 2007), and educators' dedication to engage collaboratively, interpret evidence, critically reflect, and develop collective responsibility (Hattie, 2012).

Investigations of interventions incorporating PLCs have indicated positive influences on teachers (Prenger, Poortman, & Handelzalts, 2019) and student learning (Gwinn & Watts-Taffe, 2017; Lomos, Hofman, & Bosker, 2011). A mixed-methods investigation of 23 PLCs in the Netherlands, which included 276 teachers of various grade levels, indicated moderately positive effects on teachers' knowledge, skills, attitudes, and applied practices (Prenger, et al., 2019). In a second example, a qualitative investigation of a PLC intervention that focused on vocabulary development for elementary school students in Minnesota better prepared 12 teachers to plan and deliver vocabulary instruction and was perceived by teachers to have positively influenced student outcomes (Gwinn & Watts-Taffe, 2017). Further, in a meta-analysis of five studies from 1996 to 2005 that investigated the effect of PLCs on student learning in secondary schools, Lomos and colleagues (2011) used a random effects model to report a significant coefficient Z of .12 ($p < .05$) and a small but significant summary effect ($d = .25$, $p < .05$); thus, suggesting school-based PLCs can enhance student learning. Although these studies indicate the potential for PLCs to positively influence teachers and students, there is a dearth of PLC intervention literature specific to AP contexts, with the exceptions of two important investigations (Flores & Gomez, 2011; Frumin et al., 2018).

A case study of an urban California school investigated student perceptions of substantial AP expansion efforts from 2008-2010 (Flores & Gomez, 2011). During this school's push to expand its AP Program, several interventions were implemented, including an PLC for AP teachers. The AP PLC provided opportunities for teachers to vertically team and align AP curricula within and across disciplines, in an effort to provide students with improved knowledge and skill backgrounds when they enroll in subsequent AP courses. This AP PLC also allowed for relatively experienced AP teachers to share best practices and to help train less experienced AP teachers on scaffolding techniques, whereby teachers used differentiated instruction so learners at all levels can engage with and learn rigorous content (Flores & Gomez, 2011). Similarly, an AP PLC may allow for less experienced AP teachers to learn in their ZPD (Vygotsky, 1978) from more experienced AP teachers. In addition to in-person PLCs, effective collaboration among AP teachers can occur online.

The AP Teacher Community (APTC) is an online AP PLC operated by the College Board that is available to all AP teachers nationally (Frumin et al., 2018). AP teachers use the APTC to discuss strategies, ask and answer questions, and share resources (Frumin et al., 2018). A mixed-methods investigation of various types of PL available to AP teachers found the APTC was positively associated with teachers' shifts in practice and gains in students' AP exam scores (Frumin et al., 2018). Researchers used survey (N = 10,513) and case study (n = 34) data to investigate the effect of teacher engagement with the APTC by comparing the difference between the mean AP exam scores of the group of students whose teachers did participate in the APTC and the group of students whose teachers did not participate in the APTC. Among the five comparisons of AP science exams in 2014 and 2015, four mean differences resulted in statistically significant higher means for students whose teachers participated in the APTC (n = 5,543) compared to students whose teachers did not participate in the APTC (n = 4,970), as shown in table 3.3 (Frumin et al., 2018, p. 411).

Table 3.3

Comparison of AP Exam Performance Between Students Whose Teachers did or did not Participate in the APTC

Year	Subject	Mean difference[a]	SE	Significance
2014	AP Biology	0.08	0.03	$p < .05$
2014	AP Chemistry	0.09	0.03	$p < .01$
2015	AP Biology	0.20	0.05	$p < .001$
2015	AP Chemistry	0.07	0.04	*ns*
2015	AP Physics	0.16	0.04	$p < .001$

Note. Adapted from "Adapting to large scale changes in Advanced Placement Biology, Chemistry, and Physics: The impact of online teacher communities," by Frumin et al., 2018, *International Journal of Science Education, 40*, p. 411. Copyright 2018 by Routledge.
[a]Mean difference = group of students whose AP teachers who did participate in the APTC minus group of students whose AP teachers who did not participate in the APTC

Although Frumin and colleagues' (2018) findings generally indicated a positive effect of the APTC on student AP exam performance, the study does not address the PL that was *not* experienced by 47% of the AP teachers surveyed who did not use the APTC. The needs assessment of the present study revealed several AP teachers perceived the APTC as impersonal, inconvenient, and overwhelming, which may influence AP teachers' desire (or lack thereof) to participate in the APTC. Further, of the 53% of AP teachers who took advantage of the APTC for collaboration, 59% were identified as lurkers (i.e., participants who do not post; Frumin et al., 2018). AP teachers who merely lurk on the APTC neither fully engage in active learning, participate in two-way collaboration, nor engage in dialogue with experts; all features that are critical components of effective PL (Darling-Hammond et al., 2017). Perhaps a school- or district-level AP PLC may offer AP teachers an opportunity to engage in content, curricular, and pedagogical learning in their ZPD with the help of others (Vygotsky, 1978). Such a local AP PLC may mitigate teachers' perceptions of the AP PLC being overwhelming and impersonal, as it could be based on teacher need and may help teachers develop a sense of shared responsibility that is important for PLCs (Hord, 1997).

Summary of PLC Intervention Literature

PLCs provide teachers with opportunities to collaborate with colleagues to improve teacher knowledge, skills, and practices, which should positively influence student outcomes (Darling-Hammond, 2017). Sustained, situated collaboration within a PLC framework may allow for AP teachers to regularly engage in active learning and dialogue with other AP teachers, promoting learning facilitated by others in each teacher's ZPD (Vygotsky, 1978). The needs assessment indicated AP teachers and principals appreciated the need for collaboration, but also indicated an existing lack of opportunity for AP teacher to regularly collaborate—an AP PLC may be an intervention to address this perceived need. Two key studies (Flores & Gomez, 2011; Frumin et al., 2018) described successes and limitations to PLC interventions in AP contexts that may be useful to inform a potential AP PLC intervention in the context under investigation. A second field of intervention literature, project-based learning, will next be explored.

Project-Based Learning Intervention Literature

Teachers should be guided toward employing innovative classroom practices which enhance student learning (Fischer et al., 2018a). PBL is such an innovative instructional practice that may better prepare students for success in AP courses by offering a student-centered alternative to teacher-centered practices (Parker et al., 2013). The needs assessment presented in Chapter 2 indicated that although AP teachers recognize the value of student-centered lessons (e.g., PBL), some AP teachers do not feel they possess the capacity or opportunity to develop effective PBL lessons. Thus, PL for teachers designed to increase teachers' effective incorporation of PBL practices in their AP courses represents a potential point of intervention to improve teachers' capacity to better prepare students for success in AP courses. In this PL focused on PBLs, AP teachers would be learning innovative, student-centered instructional strategies, facilitated by experts, in their zone of proximal development (Vygotsky, 1978). Practical application of an intervention involving PBL in AP courses would require teachers receive PL about how effective PBL is structured, how to infuse PBL into lessons, and sustained support in these areas. A review of literature involving PBL is summarized in Table 3.4 and is synthesized next.

Table 3.4

Project-Based Learning Literature Reviewed

Topic	Sources
Framework for project-based learning	Duke et al., 2016; Parker, 2018; Parker & Lo, 2016; Saye, 2017
Empirical studies using project-based learning in AP contexts	Fisher et al., 2018a; Parker et al., 2013
Considerations to acknowledge before implanting a project-based learning intervention	Desimone & Garet, 2015; Fischer et al., 2018a; Fischer et al., 2018b; Saye, 2017

Academic courses designed with projects as the focal point provide opportunities for adaptive, cyclical instruction (Parker, 2018). Following investigations of interventions in AP courses using PBL, Parker (2018) articulated five key design elements for successfully implementing PBL. First, students should be immersed into projects as soon as possible, and the projects should continue to be the focal point of lessons, functioning to teach core knowledge and skills. Second, core concepts or themes within a course should be identified and emphasized throughout the course. Third, curricular design that focuses on looping or spiraling content allows for deeper learning through iteration of core concepts and skills. Fourth, learning from texts is mandatory, but due to the wide range of reading ability levels, various factors must be considered for successful learning from texts, including strategic text selection, purpose setting, text-task alignment, and using multiple resources. Finally, engagement in the project should come prior to students' learning the essential content. These PBL design elements espoused by Parker result from analysis of several investigations of AP courses integrating PBL.

Inquiry-based lesson designs, such as PBL, have been integrated in AP courses and demonstrated positive influences on student outcomes (Parker et al., 2013). A mixed-methods, quasi-experimental investigation compared AP exam score outcomes for two similarly achieving, suburban high schools in the pacific northwest (Parker et al., 2013). Students' AP United States government and politics exam scores from the school that used PBL instructional designs (n = 89, $\bar{x}$ = 2.33) were higher (t[7] = 3.12, p = .018) than students' AP exam scores for the other school, which employed traditional, teacher-centered instructional methods (n = 87, $\bar{x}$ = 2.03; Parker et al., 2013).

PBL course designs may better engage students in deeper, more meaningful learning (Duke et al., 2016; Parker & Lo, 2016) and enhance student motivation and engagement in learning (Saye, 2017). Although PBL and other inquiry-based lesson designs may have traditionally been employed in STEM disciplines, PBL has become increasingly common and successful in developing durable learning in other disciplines as well, which correspond to the broad disciplinary range of AP courses (Duke et al., 2016). Duke and colleagues (2016) helpfully present guidelines for developing PBL units for any curriculum: (a) identify needs or opportunities in the school or community, (b) determine the standards to address in the projects, (c) consider real-world skills and applications beyond the standards, (d) narrow the focus to an authentic audience and purpose, (e) integrate meaningful content and literacy skills, (f) make the project the spine of the curriculum, and (g) incorporate pedagogical skills that would normally be applied to other lesson formats. Parker & Lo (2016) present a PBL curricular model for deeply engaging AP government students in weeks-long PBL cycles. The authors propose this model is more accessible than traditional lesson formats to the increasing volume of AP students, which is due to the AP expansion efforts that are de-tracking access to AP courses in many school systems. The authors place an emphasis on learning from text to enhance the rigor of cyclical project-based simulations. In addition to producing deep, meaningful learning, PBL may enhance student motivation for learning; the nature of inquiry-based investigations may require more investment from students than traditional lesson designs, which may positively contribute to student motivation to learn (Saye, 2017). Further, the real-world applications and connections that can be accessed through PBL may better motivate students to learn compared to the more abstract learning processes of traditional lesson designs (Saye, 2017). Despite this evidence that supports integration of PBL in AP courses, there are several caveats to consider.

Researchers have identified several considerations that must be acknowledged before implementing a PBL intervention (Desimone & Garet, 2015; Fischer et al., 2018a; Fischer et al., 2018b; Saye, 2017). Overall, implementing inquiry lessons is challenging for teachers (Fisher et al., 2018a) and developing inquiry-based lessons places additional time, energy, and cognitive demands on teachers (Saye, 2017). The PL literature suggested changing procedural classroom behavior (e.g., adding retrieval practice opportunities to the end of lessons) is more immediately possible for teachers than changing to implementation of inquiry lessons (Desimone & Garet, 2015). Further, teachers may not feel prepared to incorporate changes to instructional practices without substantial training or professional learning opportunities (Fisher et al., 2018a), which could be financially costly and logistically challenging. This limitation was noted in the context under investigation as some AP teachers did not perceive adequate instructional time, planning time, nor the capacity to effectively infuse PBL into AP courses. Similarly, teacher professional learning is needed to increase the enactment of inquiry-based practices in AP science courses (Fisher et al., 2018b). Therefore, administrators should allow teachers multiple years of implementation to refine and adapt to new innovative instructional designs (Fisher et al., 2018a). Finally, further research is necessary to determine if PBL is the most effective innovative instructional practice to increase student learning (Fischer et al., 2018b).

Summary of PBL Intervention Literature

Innovative teacher practices, such as inquiry-based lessons that feature PBL, have been shown to positively influence student outcomes in AP science (Fischer et al., 2018a) and AP social studies (Parker et al., 2013; Parker, 2018; Parker & Lo, 2016) contexts. Guidelines for developing effective PBLs have been put forth by Parker (2018) and Duke et al., (2016), which may guide an intervention that incorporates PBLs. Such an intervention would require PL for AP teachers to learn how to structure and implement PBLs in their courses. Developing and implementing inquiry-based lessons presents various challenges for AP teachers (Desimone & Garet, 2015; Fischer et al., 2018b; Saye, 2017), and influences on student outcomes may take multiple years to realize (Fischer et al., 2018a). A third field of intervention literature, retrieval practices strategies informed by SoL research, will be explored next.

Science of Learning Intervention Literature

The SoL field draws on research from a wide range of disciplines, including neurology, psychology, education, classical cognitive science, and philosophy, and is broader in scope than similar fields previously defined, such as mind, brain, and education, educational neuroscience, and cognitive psychology (Horvath, Lodge, & Hattie, 2017). Further, SoL places more emphasis on translational research to directly influence classroom settings compared to these related fields. Major goals of SoL include determining principles of how people learn, aligning these learning principles with educational practice, developing new practices that incorporate these learning principles, and clarifying biological processes involved in learning (Horvath, Lodge, & Hattie, 2017). A summary of the SoL literature reviewed is presented in Table 3.5 and is discussed next.

Table 3.5

Science of Learning Literature Reviewed

Topic	Sources
Science of learning framework	Horvath & Lodge, 2017; Horvath, Lodge, & Hattie, 2017
Factors that influence how well students learn	Bjork & Bjork, 2014; Garrett, 2015; Greer, 2017; Kang, 2017; Posner, Rothbart, and Rueda, 2014; Putnam, Nestojko, & Roediger, 2017; Roediger & Pyc, 2012; Yan, Clark, & Bjork, 2017
Retrieval practice enhances student learning	Agarwal & Roediger, 2018; Bjork & Bjork, 2014; Karpicke & Blunt, 2011; Roediger & Butler, 2010; Roediger & Karpicke, 2006
Students commonly use relatively ineffective study strategies compared to retrieval practice	Hartwig & Dunlosky, 2012; Karpicke, Butler, & Roediger, 2009; Kornell & Bjork, 2007
Retrieval practice has benefits on future recall of knowledge	Experimental studies: Karpicke & Blunt, 2011; Pan, Gopal, & Rickard, 2015; Roediger et al., 2011; Roediger & Karpicke, 2006 Situated studies: Bobby & Meiyappan, 2018; Roediger et al., 2011
Retrieval practice benefits later transfer of knowledge	Agarwal et al., 2012; Butler, 2010; McDaniel et al., 2013
AP-specific benefits of retrieval practice	Agarwal et al., 2014; Agarwal et al., 2017
Retrieval practice instructional frameworks to inform teachers	Firth et al., 2018; Morano, 2019; Roediger & Pyc, 2012

The translation of SoL research to educational practice spans in scope from informing teachers and students of specific behaviors teachers and students should do to maximize learning potential (i.e., prescriptive translation) to helping teachers or students understand *why* certain behaviors maximize learning potential (i.e., conceptual translation; Horvath & Lodge, 2017). Some SoL researchers (see Busso & Pollack, 2015; Devonshire & Dommett, 2010) argue educators must be knowledgeable of neuroscience to employ SoL learning principles, but that expectation may be impractical for most educators, considering the limited resources for PL (Horvath & Lodge, 2017). Therefore, in-depth neurological knowledge is not necessary to positively influence educators' practice using SoL principles; rather, through prescriptive translation, educators can focus on learning about and incorporating the SoL principles that may positively influence student learning outcomes (Horvath & Lodge, 2017). This section provides an overview of some factors and pedagogical strategies that influence how students learn, as informed by SoL research. Then, a detailed literature synthesis of one of those factors, retrieval practice strategies, will be presented.

Factors that influence how well students learn. SoL research has investigated several factors and related pedagogical strategies that influence how well students learn, including motivation, self-regulation, attention (Greer, 2017), and retrieval practice learning and studying strategies (Putnam et al., 2017; Yan et al., 2017). This section describes each of those factors, along with each factor's appearance in schools, benefits, possible risks, and availability to observe in a classroom research setting.

Motivation refers to the driving force that influences people to do things, and can be intrinsic (i.e., coming from within) or extrinsic (i.e., coming from an external source; Greer, 2017). Although schools and educators often provide extrinsic motivation for their students (e.g., grades, rewards for good performance), substantial research has suggested external rewards may sometimes decrease intrinsic motivation (Greer, 2017). However, some external rewards are appropriate to help motivate and encourage students, such as task-focused feedback (Greer, 2017), which should be provided in a way to encourage a growth mindset (Dweck, 2006). For example, telling a student "You worked really hard on that" emphasizes the student's effort, which encourages a growth mindset because the student perceives their effort enhances their capability to grow and develop (Dweck, 2006). Contrastingly, telling a student "You are really smart" emphasizes the student's innate intelligence, which encourages a fixed mindset because the student perceives their intelligence and ability are not likely to change (Dweck, 2006). Further, motivation may be positively influenced by appropriate social interactions that schools and educators can foster (Greer, 2017). Although enhancing student motivation has been suggested by SoL research to positively influence student outcomes, motivation is a complex construct intertwined with other personal constructs, perhaps making enhancing student motivation difficult to influence through an intervention with teachers.

Self-regulation refers to the ability to control one's impulses pertaining to monitoring one's thoughts, emotions, and behavior (Posner, Rothbart, and Rueda, 2014). Students with high self-regulation skills are able to inhibit behaviors that are counterproductive to their plans or goals (Greer, 2017). Teachers can support students in developing self-regulation by providing opportunities for students to learn independently, which enhances autonomy in the classroom (Greer, 2017). Further, teachers can help students set clear goals and model metacognitive functions—being aware of one's own thought processes as one learns is important to develop autonomy—to enhance students' self-regulation abilities (Greer, 2017). Similar to motivation, self-regulation is a complex construct intertwined with other personal constructs, perhaps making increasing levels of self-regulation in students difficult to influence through an intervention with teachers.

Attention refers to a cognitive process in which the brain focuses on certain inputs to accommodate for limited attentional resources (Garrett, 2015). Attention is a critical component of learning and has been shown to contribute substantially to positive learning outcomes (Greer, 2017). Teachers can utilize instructional practices that maximize student attention, such as establishing clear learning expectations, reducing distractions, providing students with choices about their learning to enhance interest, and offering opportunities for social interactions (Greer, 2017). Similar to motivation and self-regulation, attention is a complex construct intertwined with other personal constructs, perhaps making enhancing attention in students difficult to influence through an intervention with teachers. Further, a PL intervention that focuses on students' motivation, self-regulation, or attention may require teachers to make substantial changes to their practice, which may be difficult to achieve in a short-term intervention with teachers.

In contrast, a body of research (e.g., Agarwal & Roediger, 2018; Morano, 2019; Roediger & Butler, 2011; Roediger & Pyc, 2012) has identified retrieval practice learning and studying strategies that may positively influence student learning while requiring teachers to make relatively minor changes to their practice, in comparison to changing students' personal characteristics (Putnam et al., 2017). Retrieval practice is the process of actively calling information to mind rather than rereading it (Roediger & Butler, 2011). Despite ample evidence suggesting retrieval practice improves long-term retention and later transfer of knowledge, many students are unaware of these strategies (Agarwal & Roediger, 2018) and their benefits on learning (Karpicke & Roediger, 2008). Additionally, without support, students may choose not to use retrieval practice strategies because the act of calling information to mind produces a perceptible level of difficulty (Karpicke, Blunt, & Roediger, 2009). This phenomenon is known as desirable difficulty, which refers to the presence of a considerable but manageable level of challenge while completing a task (Bjork & Bjork, 2014). Importantly, desirable difficulty enhances learning and performance, which indicates retrieval practice may positively influence student academic outcomes (Bjork & Bjork, 2014; Yan et al., 2017). Teachers can infuse retrieval practice strategies in their classes in various ways, including using low-stakes quizzes, asking students to recall what they know during class before students look up the content in a source (e.g., notes or book), and modeling for students how to study using high- or low-technology flashcards instead of re-reading text (Putnam et al., 2017). Retrieval practice strategies can seamlessly incorporate complementary strategies, such as interleaving practice (e.g., mixing different kinds of examples or problems during practice; as opposed to massed practice which groups together problem types during practice), to further enhance student learning (Kang, 2017). Similarly, retrieval practice can seamlessly incorporate spacing practice over time; providing time to pass between practice may create a desirable difficulty for recall which enhances durable learning (Yan et al., 2017). Similarly, delaying feedback to students may permit some forgetting to occur; thereby, enhancing learning through incorporating a desirable level of difficulty (Yan et al., 2017). Collectively, retrieval practice learning and studying strategies—as well desirable difficulty, interleaving practice, spacing practice, and delaying feedback—have been shown to enhance durable learning and later transfer of knowledge (Horvath, Lodge, & Hattie, 2017).

Teacher practices that may enhance certain constructs from SoL research (i.e., motivation, self-regulation, attention) may be difficult to influence through a PL intervention.

However, influencing teachers' effective application of retrieval practice learning and studying strategies in their practice, along complementary strategies (e.g., spacing, interleaving, and including desirable difficulty and feedback), may be feasible through a PL intervention. It is important to preface the following retrieval practice literature review with a distinction between students' *performance* and *learning*. That is, although a student may have *performed* well on a quiz because information is currently available in their mind, that does not necessarily indicate the student has *learned* the content (i.e., how well the information was encoded into memory and linked to existing knowledge; thereby, allowing for flexible future retrieval; Yan et al., 2017). Thus, the retrieval practice literature considered next describes how to enhance student learning beyond merely performing well on assessments shortly following instruction.

Retrieval practice intervention literature. Substantial SoL research has focused on retrieval practice and complementary learning and studying strategies (Agarwal & Roediger, 2018). Improving understandings of how teachers can optimally manage student learning—and how students can better self-regulate their own learning—have become increasingly important areas of education research (Bjork, Dunlosky, & Kornell, 2012). Retrieval practice is a learning and studying strategy that has been shown to positively influence durable learning (Agarwal & Roediger, 2018; Roediger & Butler, 2011). This literature review section will discuss nuanced strategies informed by SoL research related to the benefits of retrieval practice.

Retrieval practice enhances student learning. Retrieval practice can be overlapped with four complementary, powerful strategies for teaching and learning that have emerged from SoL research: feedback, spaced practice, interleaved practice, and desirable difficulty. Although this section of intervention literature will focus on retrieval practice, other powerful strategies are often used in conjunction with retrieval practice in the literature, so it is useful to briefly explain the benefits of those additional strategies. Feedback may facilitate learning by providing diagnostic information to students about what they do or do not know, as well as by influencing students' metacognition (i.e., students' understanding of their own learning; Agarwal & Roediger, 2018). Spacing learning opportunities over time, as opposed to massed practice, may enhance learning by allowing time for knowledge to be consolidated and refreshed. Interleaving practice (i.e., mixing of skills) may appear to initially slow learning progress, but over time, may lead to more durable learning by helping students develop relationships and distinctions between related concepts (Agarwal & Roediger, 2018). Finally, incorporating desirable difficulty in retrieval practice may enhance long-term retention, and can be accomplished by spacing and interleaving practice (Bjork & Bjork, 2014).

Retrieval practice may help solidify and expand information by repeatedly pulling out information from stored memory, as opposed to rereading which attempts to cram in more information (Agarwal & Roediger, 2018). In this way, retrieval practice is cognitively performed by students when taking tests. Tests traditionally have been viewed in education as mechanisms of assessment; however, recent research has indicated that taking low-stakes tests intermittently enhances later performance on tests relative to rereading the material, a phenomenon known as the testing effect (Roediger & Butler, 2010). The method of low-stakes testing can range from informal studying alone to formal activities in a class, but commonly employs retrieval practice (Agarwal & Roediger, 2018). Thus, advancing students' learning and studying strategies may occur through leveraging the understanding that retrieval not only can be used to measure knowledge, but also to produce learning (Karpicke & Blunt, 2011). This enhanced learning could positively affect students' test performance generally and AP exam performance, specifically.

SoL research focused on retrieval practice has occurred both experimentally in laboratory settings and in contextualized educational settings. Various studies have indicated college students most commonly use relatively ineffective study strategies (e.g., rereading, highlighting, and underlining) compared to more effective retrieval practice-based study strategies (Hartwig & Dunlosky, 2012; Karpicke, Butler, & Roediger, 2009; Kornell & Bjork, 2007). Similarly, the needs assessment presented in Chapter 2 revealed AP students in high school would benefit from instruction on how to optimize studying for later recall and transfer.

The benefits of using retrieval practice to enhance learning, memory, recall, and transfer have emerged from SoL research in recent years (Agarwal & Roediger, 2018). Retrieval practice may offer optimization of students' learning and studying time in and out of class (Roediger & Blunt, 2010; Roediger & Karpicke, 2006), which may offer an important opportunity for AP students. In the needs assessment, schools reported recently implementing efforts to increase supports of AP students (e.g., writing, note-taking, and organizational strategies); however, teachers reported concerns regarding the success of these efforts, none of which involved effective learning or studying strategies from the SoL literature (e.g., retrieval practice). Further, the needs assessment revealed AP teachers perceived students, in general, do not know how to study effectively. Thus, PL designed to improve AP teachers' understanding and implementation of studying and learning strategies such as retrieval practice represents a potential point of intervention to improve teachers' capacity to better prepare students for success in AP courses. In this potential intervention, AP teachers would receive PL from experts in teachers' ZPD (Vygotsky, 1978) focused on optimal learning and studying strategies. Practical application of an intervention involving learning and studying strategies informed by SoL research would include PL for teachers on how effective retrieval practice activities may be structured, how to infuse retrieval practice into lessons, and how to instruct students on effective retrieval practice strategies when studying on their own. The various benefits of retrieval practice on student learning are synthesized in the following sections.

Retrieval practice benefits future recall of knowledge. Although interventions implementing retrieval practice situated specifically in AP contexts are not yet present in the literature, an abundance of recent studies have investigated effects of retrieval practice on student learning; several examples of important experimental (i.e., Karpicke & Blunt, 2011; Pan, Gopal, & Rickard, 2015; Roediger & Karpicke, 2006) and situated studies (i.e., Bobby & Meiyappan, 2018; Roediger et al., 2011) will be presented in this section.

Pan and colleagues (2015) conducted a series of four experiments with college students to compare the influence of studying using rereading to the influence of studying using retrieval practice with feedback—in the form of fill-in-the-blank questions—on later recall of facts from AP history and AP biology content. Across all four experiments, the facts were approximately 11 words long and included multiple who, what, when, where, or why components. Across the first three experiments, participants initially learned 36 facts and then either studied by rereading or studied by retrieval practice one time for each fact (except the biology facts in experiment two were studied twice); the final test was taken 48 hours after initial learning. In the first experiment, participants ($N = 38$) learned facts from AP world history and AP United States history and the final test consisted of fill-in-the-blank questions. The mean proportion of correct responses on the final test was 38% higher for the group that studied by retrieval practice compared to the group that studied by rereading ($p < .05$). In the second experiment, participants ($N = 58$) learned facts from AP biology and the final test consisted of fill-in-the-blank questions. The mean proportion of correct responses on the final test was 38% higher for the group that studied by retrieval practice compared to the group that studied by rereading ($p < .05$). In the third experiment, participants ($N = 52$) learned facts from AP world history and AP United States history and the final test consisted of multiple-choice questions. The mean proportion of correct responses on the final test was 29% higher for the group that studied by retrieval practice compared to the group that studied by rereading ($p < .05$). In the fourth experiment, 54 facts were used, the final test was taken 24 hours after initial learning, and each fact was studied twice after initial learning. These procedural changes were made to accommodate the experimental variation of the final test including multiple critical terms per fact that participants attempted to recall. Participants ($N = 45$) learned facts from AP world history and AP United States history and the final test consisted of fill-in-the-blank questions. The mean proportion of correct responses on the final test was 41% higher for the group that studied by retrieval practice compared to the group that studied by rereading ($p < .05$). Collectively, these four experiments by Pan and colleagues suggest AP content may be better recalled following studying by retrieval practice compared to studying by rereading.

One experimental study that examined retrieval practice included two experiments with college students aimed to determine if retrieval practice or elaborative studying with concept mapping produced more durable learning (Karpicke & Blunt, 2011). In the first experiment, groups of students ($N = 80$) either: (a) studied a text only once, (b) studied the text then reread in three additional study periods, (c) studied the text initially then created a concept map of the concepts as an elaborative study technique, or (d) studied the text initially then practiced retrieval multiple times. Although the study did not cite the analysis performed, the authors reported a partial eta squared, which is most likely the result of an ANOVA. On the final test one week later, which included verbatim and inference questions, the results indicated that students who studied with retrieval practiced scored, on average, higher on the final test (*M* = 67%) compared to students who studied with elaborative concept mapping (*M* = 45%), indicating approximately a 50% improvement of retention [*d* = 1.50, $F_{1,\,38}$ = 21.63, η_p^2 = 0.36]. Further, speaking to the notion that students have misconceptions about optimally effective study strategies, students predicted repeated rereading of the text would produce the best long-term learning and retrieval practice would produce the worst learning; however, the opposite was found in this study. In the second experiment, researchers used a within-subject design of college students (*N* = 120); each student created a concept map of one text and practiced retrieval for a second text. The retrieval practice advantage was large compared to concept mapping when the final test included short-answer questions [*d* = 1.07, $F_{1,59}$ = 68.54, η_p^2 = 0.54]. Similarly, the retrieval practice advantage was large compared to concept mapping even when the final test included concept mapping [*d* = 1.01, $F_{1,59}$ = 58.42, η_p^2 = 0.50]. Again, students demonstrated a misconception of effective study methods, as 75% of students predicted elaborative concept mapping would be equal or more effective than retrieval practice (Karpicke & Blunt, 2011).

A similar investigation combining two experiments of Washington University college students aimed to determine if retrieval practice via testing or repeated studying produced better retention of academic content (Roediger & Karpicke, 2006). In the first experiment, participants (*N* = 120) initially learned prose passages then engaged in study periods of either studying (i.e., rereading) the text again or being tested on it (without feedback). Students' retention was measured after five minutes, two days, and seven days. Students who studied using repeated rereading scored higher, on average, on the test five minutes after initial learning (*M* = 81%), compared to students who studied using retrieval practice via testing (*M* = 75%; *t*[39] = 3.22, *d* = 0.52). However, students who studied using retrieval practice via testing scored higher, on average, on the test two days after initial learning ($M = 68\%$), compared to students who studied using rereading ($M = 54\%$; $t[39] = 6.97$, $d = 0.95$). Similarly, students who studied using retrieval practice via testing scored higher, on average, on the test seven days after initial learning ($M = 56\%$), compared to students who studied using rereading ($M = 42\%$; $t[39] = 6.41$, $d = 0.83$). Thus, retrieval practice was shown to produce better retention compared to repeated studying using rereading on delayed tests that were two and seven days after initial learning.

In Roediger and Karpicke's (2006) second experiment, participants ($N = 180$) either: (a) studied a passage four times, (b) studied a passage three times and took one test, or (c) studied a passage one time and took three tests. Then, participants took a final test either five minutes or seven days after initial learning. Like the first experiment, on the test taken five minutes after initial learning, the students who studied four times scored higher, on average, on the final test ($M = 83\%$) compared to the students who studied one time and took three tests ($M = 71\%$; $t[58] = 2.24$, $d = 1.22$). The students who studied three times and took one test also scored higher, on average ($M = 78\%$) compared to the students who studied one time and took three tests ($M = 71\%$; $t[58] = 2.24$, $d = 0.59$). However, on the test taken seven days after initial learning, the students who studied one time and took three tests scored higher, on average, on the final test ($M = 61\%$) compared to the students who studied four times ($M = 40\%$; $t[58] = 4.78$, $d = 1.26$). Similarly, the students who studied three times and took one test scored higher, on average, on the final test ($M = 56\%$) compared to the students who studied four times ($M = 40\%$; $t[58] = 3.21$, $d = 0.82$). Even without feedback, students demonstrated better long-term retention from retrieval practice via testing than from repeated studying (Roediger & Karpicke, 2006). The benefits of retrieval practice are well established in experimental settings and have also been evaluated in classroom settings using authentic curricular material.

An investigation of suburban sixth grade students ($N = 142$) aimed to determine if quizzing (i.e., a mechanism of retrieval practice) helped promote learning of social studies content (Roediger et al., 2011). Using a within-subjects design, students were given quizzes following lessons on only portions of the content (i.e., tested content); the teacher was blind to the tested and non-tested content. Student retention of tested versus non-tested content was measured at various intervals after initial learning, but the long-term retention measured by end-of-semester exams may be most generalizable to an AP context. Analysis of variance indicated that the mean scores on content that had been previously tested (79%) was higher than the mean scores on content that had not been previously tested (67%; $F[1,35] = 28.73$, $\eta_p^2 = 0.45$).The following year in the same school, a second study was conducted with sixth grade social studies students ($N = 132$). Like the first study, the teacher was blind to what was tested and non-tested content using a within-subjects design; however, this intervention encouraged students to quiz themselves online using researcher-created questions during and after school as the mechanism of retrieval practice. Long-term retention, measured by end-of-semester exams, was greater for the mean scores on content that had been previously tested (74%) than for the mean scores on content that had not been previously tested (65%; $F[1,65] = 16.58$, $\eta_p^2 = 0.20$). Thus, teachers can use retrieval practice in class lessons and teachers can establish opportunities for students to practice retrieval online to promote durable learning on a months-long time scale in a classroom setting (Roediger et al., 2011). Intervention studies featuring retrieval practice in higher education settings have also been reported in the literature.

An investigation of first year Bachelor of Medicine – Bachelor of Surgery students ($N = 237$) aimed to compare the effectiveness of a form of retrieval practice (i.e., open-book exam) on learning in a biochemistry course to self-studying (Bobby & Meiyappan, 2018). Using a within-subjects design, students were given a pre-test on the content, then subjected to either an open-book exam or self-study, both for one hour, followed by a closed-book posttest to determine relative gain in knowledge retained after one week. Paired *t* tests results were disaggregated into various categories of ability level and content topics and not presented succinctly overall; however, the overall mean gain in student scores for open book exam content was approximately double the mean gain in student scores for self-studied content. Additionally, students perceived the open-book exam method of retrieval practice as better than self-study in both providing a helpful structure to studying and reinforcing the concepts (Bobby & Meiyappan, 2018). Using an open-book exam strategy as a form of retrieval practice may be generalizable to AP contexts, as long as students are actively practicing retrieval and not simply looking up answers without effortful retrieval. Not only has retrieval practice been shown to improve retention, but retrieval practice also may positively influence transfer of knowledge.

Retrieval practice benefits later transfer of knowledge. One potential criticism of employing retrieval feedback could question if retrieval practice merely improves rote memorization by training people to produce fixed responses from a given cue (Roediger & Butler, 2011). In response to this concern, several studies (Agarwal et al., 2012; Butler, 2010; McDaniel et al., 2013) have found that retrieval practice not only enhances later recall of knowledge, but also that retrieval practice promotes the transfer of knowledge (i.e., the ability to solve a problem or generalize learning from one context to apply that learned information in a different way; Roediger & Butler, 2011).

Demonstrating the effect of retrieval practice on transfer, McDaniel and colleagues (2013) conducted two experiments situated in the same suburban, middle-class, Midwestern, public middle school; the first experiment assessed students' near transfer of knowledge to different question formats, and the second experiment assessed students' ability to transfer understanding of concepts to a variety of contexts. The first experiment consisted of six classes of grade 7 science students (N = 142). The within-subjects design divided all course content topics into three different categories, to which the teacher was blinded: (a) content quizzed using definition-response questions (i.e., multiple choice questions with definition statements as answer choices), (b) content quizzed using term-response questions (i.e., multiple choice questions with single words as answer choices), and (c) content not quizzed. Students used clickers for three quizzes spaced over each of three units of study (M = 11 days); feedback was provided to students after each question. Performance (i.e., percent of questions answered correctly) of the analyzed sample (n = 61) for term-response unit exam questions was 82%, 82%, and 72% for term-response quizzed content, definition-response quizzed content, and non-quizzed content, respectively. Performance for definition-response unit exam questions was 79%, 82%, and 63% for term-response quizzed content, definition-response quizzed content, and non-quizzed content, respectively. ANOVA indicated performance on both term-response and definition-response unit exam questions was greater ($p < .05$) for both forms of quizzed content compared to non-quizzed content. Thus, quizzing enhanced performance for same-type and different-type questions, relative to no quizzing. Therefore, the authors asserted that spaced quizzing with feedback may improve flexible use of learned content on later exams and enable near transfer to different question formats about a concept, which may be an important skill for AP exams and course exams.

McDaniel and colleague's (2013) second experiment consisted of grade 8 science students (N = 142) and sought to determine how quizzing influences performance on unit exam application questions. Within-subjects design included divided all course content topics into three different categories, to which the teacher was blind: (a) content quizzed with term-response questions, (b) content quizzed with application questions (i.e., multiple choice questions that required students to determine the principle or construct that was illustrated in a certain novel scenario), and (c) content not quizzed. Experimental design mirrored the first experiment, except only two units of study (*M* = 16 days) were analyzed. Performance of the analyzed sample (*n* = 90) for term-response unit exam questions was 88%, 83%, and 75% for term-response quizzed content, application-quizzed content, and non-quizzed content, respectively. Performance for application unit exam questions was 78%, 82%, and 76% for term-response quizzed content, application-quizzed content, and non-quizzed content, respectively. ANOVA indicated performance on unit exam term-response questions was statistically higher ($p < .05$) for both term-quizzed and application-quizzed content, compared to non-quizzed content. However, performance on unit exam application questions was statistically higher for application-quizzed content, but not for term-response quizzed content, compared to non-quizzed content. Thus, the authors asserted spaced quizzes with feedback that used application questions were shown to be especially effective at producing learning that promoted flexible application to novel situations. This study suggested that intervention that incorporates retrieval practice should employ application questions, not only simple recall questions, to optimize the benefits of retrieval practice on AP exams and course exams.

A study that incorporated a series of four experiments involving four different groups of undergraduate psychology students (*n* = 48, *n* = 48, *n* = 24, *n* = 20) at Washington University in St. Louis sought to determine if repeated testing (i.e., one mechanism to enact retrieval practice) can promote transfer (Butler, 2010). In all four experiments, all students initially learned prose passages, then one group repeatedly studied the content, whereas the other group was repeatedly tested on the content. Students took the unit test seven days later. The level of transfer required varied among the four experiments, as the unit test questions included either: (a) the same questions as the practice tests, (b) new questions requiring transfer within the same knowledge domain (two of the experiments), or (c) new questions requiring transfer from different knowledge domains. Across the four experiments, analysis of variance indicated that performance on the unit test was greater ($p < .05$) for the students who used repeated testing compared to students who used repeated studying (Butler, 2010). These findings indicate repeated testing, as a form of retrieval practice, is effective in producing both retention and transfer of knowledge (Butler, 2010), both skills that are important for AP students.

Additional AP-specific benefits of retrieval practice. Two investigations of interventions that employed retrieval practice strategies not yet discussed indicate possible benefits that may be particularly important for AP students (Agarwal et al., 2014; Agarwal et al., 2017). One study indicated retrieval practice may have a greater positive influence on students who have relatively lower working memory capacity (Agarwal et al., 2017) and a second study indicated retrieval practice may reduce test anxiety (Agarwal et al., 2014).

An experimental investigation of 156 college students in 2008 (n = 104) and 2011 (n = 52) used 110 general knowledge questions to examine the relationship between working memory capacity and the potency of retrieval practice with and without feedback (Agarwal et al., 2017). Participants completed an initial test on the general knowledge facts, then one group studied the facts, whereas the other group was tested on the facts (with or without feedback). Individual differences in working memory capacity, measured using the automatic operation span task (i.e., a technique that uses participants' total number of letters recalled in the correct serial position to measure working memory capacity), ranged from 10 to 75 (M = 60.3, SD = 14.3). The final test determined retention two days after initial learning of the facts and indicated no significant correlation for the retrieval practice group that did not receive feedback, $r = -.02$, $t(37) = 0.09$, $p = .926$; however, there was a significant negative correlation for the retrieval practice group that received feedback, $r = -.42$, $t(37) = 2.79$, $p = .008$. These findings indicated that retrieval practice with feedback had a differentially greater influence for students with relatively low working memory capacity (Agarwal et al., 2017), who may represent a considerable proportion of the growing AP student population as increasing numbers of students are recruited to AP courses from intermediate level classes. Thus, retrieval practice with feedback may offer enhanced learning opportunities to improve academic outcomes for AP students who have relatively low working memory capacity.

An investigation of middle school ($n = 1,306$) and high school ($n = 102$) students sought to understand if students experienced changes in test anxiety when retrieval practice strategies are applied in their classrooms (Agarwal et al., 2014). Students in this study were from a Midwestern suburban public school district who all participated in various retrieval practice studies from 2006 to 2013. Following each study, researchers asked students to complete a survey that included questions about self-reported anxiety, which served as the data source for this investigation. Overall, 72% of students found the retrieval practice interventions made them feel less nervous for unit tests, whereas 22% of students reported the same level of nervousness and 6% of students reported the retrieval practice intervention made them feel more nervous (Agarwal et al., 2014). These findings indicate retrieval practice strategies may decrease student test anxiety, which may be experienced by students taking high-stakes tests (e.g., AP exams). Therefore, implementation of retrieval practice strategies may improve outcomes for students on AP course exams.

Retrieval practice instructional frameworks to inform AP teachers. Frameworks for applying contributions from SoL that inform effective learning and studying strategies have been proposed by several sources (Firth et al., 2018; Morano, 2019; Roediger & Pyc, 2012). This section discusses these frameworks that suggest instructional strategies and inform a potential intervention involving retrieval practice in an AP context.

Students often use study strategies that are less efficient than retrieval practice, such as rereading, highlighting, or underlining notes (Karpicke et al., 2009; Kornell & Bjork, 2007). Therefore, Roedgier and Pyc (2012) recommend a first step in enhancing students' studying strategies is to inform teachers and students of strategies that have been repeatedly shown by research to optimize learning. Although teachers can implement effective learning and studying strategies in various formats in their classroom, Roediger and Pyc suggest incorporating the overarching principles of retrieval practice by implementing via self-testing and using meaningful distribution of practice (i.e., spacing and interleaving). Morano (2019) recommends offering students five to seven opportunities for retrieval practice for important content and gradually increasing the duration between retrieval practice sessions, because consistently short intervals may not support durable learning. A key benefit of implementing effective learning strategies in the classroom is the strategies may require little financial expense (Roediger & Pyc, 2012).

Incorporating low-stakes quizzes for a class is one way of providing students with opportunities for retrieval practice, but there are several other instructional options to achieve the same goal: asking students verbal questions, promoting student self-questioning, writing notes from memory, using flashcards, writing essays, and group discussions (Firth et al., 2018). These instructional activities can be employed with technologies if available (e.g., Quizlet, Kahoot!, or

Plickers) or with low technology tools (e.g., personal whiteboards or index cards; Morano, 2019). In all these instructional activities, students must actively practice recall, not simply reread or re-expose themselves to material. Further, these activities (with the exception of writing essays) can easily provide students with feedback. Incorporating retrieval practice activities may not take away substantial instructional time nor be challenging for teachers to teach their students; further, retrieval practice activities may be likely to be used by students and may provide students with academic benefits (Firth et al., 2018).

Summary of Science of Learning Intervention Literature

SoL research focuses on understanding how people learn and aligning this understanding to educational practice (Horvath, Lodge, & Hattie, 2017). SoL literature offers ample evidence that employing retrieval practice provides opportunities to enhance students' learning and retention of knowledge (Bobby & Meiyappan, 2018; Karpicke & Blunt, 2011; Roediger et al., 2011; Roediger & Karpicke, 2006). Not only has retrieval practice been shown to increase retention, but also to facilitate transfer of stored information to novel applications (Agarwal et al., 2012; Butler, 2010; McDaniel et al., 2013). Although testing in education has a long history of being only associated with evaluation of student understanding, employing low-stakes testing as a mechanism of studying has been shown to positively influence students' academic outcomes (Karpicke & Blunt, 2011; Roediger & Butler, 2010). Structuring instructional activities so that retrieval practice is spaced over time and interleaved by mixing various skills may further optimize the learning benefits of practicing retrieval (Agarwal & Roediger, 2018). Additionally, retrieval practice has been shown to have two specific benefits that may be especially important for a growing AP student population that is being recruited from intermediate-level courses: a greater positive influence on students with relatively low working memory capacity (Agarwal et al., 2017) and a reduction in students' test anxiety (Agarwal et al., 2014). Frameworks for infusing retrieval practice strategies into instruction (Firth et al., 2018; Morano, 2019; Roediger & Pyc, 2012) have provided insights into ways a potential intervention incorporating retrieval practice may be structured. An intervention focused on retrieval practice could be productive PL for AP teachers as informed by PL literature (Darling-Hammond et al., 2017), as AP teachers would need to understand: (a) the benefits of retrieval practice, (b) how to implement retrieval practice in classes with fidelity, and (c) how to teach students to use retrieval practice when studying on their own.

Summary of Intervention Literature

The needs assessment yielded three themes related to the problem of practice that may be actionable and that informed the literature synthesis; limited opportunities for AP teachers to collaborate with colleagues, AP teachers' limited capacity to infuse inquiry-based lessons like PBLs, and AP teachers' limited capacity to help students improve their learning and studying strategies. First, because all three themes involved PL, a literature review of effective PL was presented and guided by Darling-Hammond and colleagues (2017) framework. An intervention involving PL for AP teachers would likely involve AP teachers learning socially in their ZPD with the help of others, which made sociocultural learning theory (Vygotsky, 1978) a helpful framework to guide the literature synthesis.

A literature review of interventions related to PLCs may help inform a potential AP PLC intervention as a mechanism of improving collaboration between AP teachers by providing a platform for active learning, dialogue, and sharing of best practices. A literature review of interventions related to PBL may help inform a potential intervention involving PL for AP teachers to help improve AP teachers' capacity to infuse PBL in their AP courses. A review of literature focused on retrieval practice interventions may help inform a potential intervention involving PL for AP teacher to help improve AP teachers' capacity to enhance their students' learning and studying strategies. Due to the malleable nature of PLCs, it may be possible to incorporate retrieval practice strategies in an AP PLC framework to optimize the benefit for AP students in the proposed intervention, which will be discussed next.

Overview of the Proposed Solution and Conclusions

Retrieval practice strategies that have emerged from SoL literature may have a substantial positive influence on AP student learning and outcomes. As previously discussed, many recent intervention studies in various contexts have indicated practicing retrieval improves students' retention and ability to transfer knowledge. As described in through literature, practicing retrieval can occur in a variety of formats in the classroom and when studying outside of class. To implement an intervention involving retrieval practice strategies, AP teachers would need PL to understand the academic benefits of retrieval practice, how retrieval practice can be incorporated in instructional activities, and how to teach students to use retrieval practice when studying alone. This PL may be able to be effectively delivered through an AP PLC.

It may be possible to leverage existing PL time in the context under study to implement an AP PLC that includes a component focused on retrieval practice. The broad, flexible nature of a PLC may serve as a platform for AP teachers to collaborate, engage in active learning, learn about the benefits of retrieve practice, develop ready-to-use lesson components infusing retrieval practice strategies, and learn and share best practices for implementing retrieval practices in their AP classes. Infusing retrieval practice into lessons may be done with minimal loss of instructional time, as in some cases, existing instructional activities may only need to be modified to serve as retrieval practice opportunities. In contrast, the incorporation of inquiry-based lessons, like PBLs, could require longer for teachers to learn and may require AP teachers to substantially change their curricula or pedagogical practices, perhaps leading to a longer implementation timetable and less fidelity to the intervention. Further, changing teachers' procedural classroom behavior (e.g., integrating spaced, low-stakes quizzes) may be less complex for teachers than shifting to inquiry-based instructional techniques, such as PBLs (Desimone & Garet, 2015). For instance, incorporating retrieval practice in AP teachers' lessons can be achieved by subtle modifications in their formative assessment techniques; whereas, PBLs may require substantial changes to AP teachers' instructional approach, planning, and instruction.

It is important that PL be frequent and sustained (Darling-Hammond et al., 2017), so the AP PLC may meet weekly for 30 minutes for 12 weeks to first inform AP teachers of the benefits and mechanisms of retrieval practice, model classroom activities that infuse retrieval practice strategies, support teachers in implementing retrieval practice in their classes, and support teachers in helping students more effectively study on their own using retrieval practice strategies. A malleable AP PLC may also differentially support AP teachers in areas of specific needs, as well as delve deeper into effective learning and studying strategies that augment effective retrieval practice (i.e., spacing practice, interleaving practice, effectively providing feedback, and incorporating desirable difficulty; Agarwal & Roediger, 2018). A potential intervention of an AP PLC featuring retrieval practice strategies may offer AP teachers the support needed to scaffold AP students toward utilizing enhanced learning and studying strategies, and ultimately achieving improved AP academic outcomes for all students.

Chapter 4: Intervention Procedure and Program Evaluation Methodology

Advanced Placement (AP) expansion efforts since the 1990s have greatly increased participation in AP courses; thereby, extending rigorous, college-preparatory curricula and instruction to many students (College Board, 2014; Judson & Hobson, 2015; Parker et al., 2013; Rowland & Shircliffe, 2016). However, AP expansion has been associated with a broadening AP recruitment pool that includes students without experience in advanced academic courses, leading to many students facing disadvantages when they pursue AP courses (Kolluri, 2018) and leading to decreasing AP exam pass rates (Judson & Hobson, 2015). Whereas the needs assessment presented in Chapter 2 indicated AP teachers and principals believe exposure to AP courses better prepares students for college, documented studies demonstrated that students who merely participate in AP courses but are unsuccessful on AP exams are not conferred the same academic and non-academic benefits as their AP exam passing peers (Ackerman et al., 2013; Evans, 2019; McKillip & Rawls, 2013; Morgan & Klaric, 2007; Smith et al., 2017). AP teachers require enhanced supports to better prepare all of their AP students for success in the course and on AP exams.

The needs assessment presented in Chapter 2 examined changes in AP enrollment and AP exam scores from 2014 to 2017 in the large, diverse, county-wide district (see Table 2.1) using existing data and found AP enrollment increased more than expected over the study period, (X^2 [1, N = 5,113] = 9.23, p = .0024); however, despite a decrease in AP exam scores during the three years, the change was not significant (X^2 [1, N = 4,097] = 0.73, p = 0.39). Further, semi-structured interviews with AP teachers (n = 5) and principals (n = 2) found participants perceived: (a) all AP students, including those without advanced academic backgrounds, could be capable of success in AP courses if strategic learning supports were provided; (b) collaboration among AP teachers is critical but currently inadequate; and (c) AP teachers are differentially prepared to effectively instruct AP courses. AP teachers need improved supports to facilitate student learning and success in AP courses.

An intervention was designed that addresses the salient factors uncovered in the literature review related to the problem of practice and addresses the findings from the needs assessment study, in order to facilitate AP teachers in preparing all students for success in AP courses. An AP professional learning community (PLC) intervention intended to provide AP teachers the opportunity to engage in collaborative learning with the support of colleagues; thereby, meeting individual teachers' needs by supporting each teacher in their ZPD. The AP PLC focused on brain-targeted teaching and learning practices that would translate to better course and exam performance aimed to be relevant in most content areas. One important brain-targeted practice is retrieval practice, which is a strategy that increases test performance and durable learning by having students practice recalling information from memory, which is necessary in most content areas. Improving teachers' knowledge and self-efficacy in retrieval practice strategies may increase teachers' application of the strategies in their AP classes, which may positively influence student preparedness for AP coursework and student outcomes in AP courses. Encouraging students to use retrieval practice learning and studying strategies when studying on their own may further improve preparedness and outcomes for all AP students. Collectively, the AP PLC featuring retrieval practice learning and studying strategies aimed to provide AP teachers the supports needed to address the problem of practice and the salient findings of the needs assessment study.

This chapter will first describe the research design of the intervention study—the examination of the AP PLC—which includes both process and outcome evaluation components.

Next, the methods of the study will be discussed, which includes a description of the participants and measures. Finally, the procedures of the study will be discussed, which include a description of the specific intervention components and data collection.

Research Design

This study employed a convergent parallel mixed-methods design, in which quantitative and qualitative data collection and analysis occur concurrently and independently prior to mixing the results (Creswell & Plano Clark, 2011). Convergent parallel design optimally targeted the goals of the research by obtaining different but complementary and potentially validating strands of data (Creswell & Plano Clark, 2011). Equal priority was given to both the quantitative and qualitative strands of this study. Although the sample size of the qualitative strand was less than the sample size of the quantitative strand, the participants for both strands were derived from the same target population.

Logic models present a logical argument for a program by providing linkages between resources (i.e., inputs), activities, outputs, and outcomes (McLaughlin & Jordan, 1999). Inputs are required to implement the program, and may include time, human, financial, and other resources (McLaughlin & Jordan, 1999). As shown in the logic model, (Appendix G), the AP PLC required a 90-minute initial PL session and 12 weekly 30-minute sessions, all of which occurred using virtual videoconferencing sessions. The AP PLC required supportive partnerships with the principal and assistant principals, as well as AP teachers' willingness to bring lessons to the sessions, where they collaboratively developed retrieval practice strategies.

The logic model identified the inputs that were required to support the activities (i.e., action steps needed to produce outputs) and outputs (i.e., products or services produced from the program; McLaughlin & Jordan, 1999). The AP PLC activities (see Appendix G) occurred during the 13 AP PLC sessions, which scaffolded AP teachers as they worked toward the outcomes. The activities progressed toward several goals: (a) address possible misconceptions about effective learning and studying strategies, (b) provide compelling evidence that retrieval practice strategies enhance durable recall (e.g., Bobby & Meiyappan, 2018; Roediger et al., 2011; Roediger & Karpicke, 2006) and later transfer of knowledge (e.g., Agarwal et al., 2012; Butler, 2010; McDaniel et al., 2013), (c) model basic and advanced classroom applications of retrieval practice, (d) model techniques to help students use retrieval practice when studying on their own, and (e) provide weekly collaboration with peers and the researcher using situated lessons to develop ready-to-use retrieval practice lesson components each week. All 28 AP teachers in Rathton High School (RHS; a pseudonym) were invited to volunteer to participate in the AP PLC that was designed to produce several outcomes.

The logic model identified several assumptions for the AP PLC and external factors over which the researcher had limited control (see Appendix G). The assumptions included: (a) AP teachers will have a growth mindset (Dweck, 2006) and be willing to engage in the sessions, (b) AP teachers will incorporate retrieval practice strategies in their lessons, (c) AP teachers will be willing to self-report both the frequency of their use of retrieval practice strategies and the aggregated mean student scores from select unit exams in 2019 and 2020, (d) the time provided for the AP PLC is adequate to positively influence the intended outcomes, and (e) the mode of instruction (i.e., in-person) will remain consistent through the completion of the study. The external factors included: (a) other school initiatives may not align with the logistics of implementing the AP PLC as intended, (b) the frequency of AP PLC sessions may lead to attrition of participants, (c) the IRB may not approve all requested methods and procedures data, and (d) maturation in AP teachers and students may occur over time.

The logic model identified the outcomes (i.e., changes that result from the outputs; McLaughlin & Jordan, 1999) of the AP PLC (Appendix G). The outcomes indicated in the theory of change (Figure 4.1; see Leviton & Lipsey, 2007) included improved AP teacher knowledge of retrieval practice strategies and AP teacher self-efficacy for using retrieval practice strategies. These outcomes may have increased AP teachers' classroom application, modeling, and encouragement of retrieval practice strategies, which in turn may have enhanced AP students' learning and studying methods, resulting in improved performance in AP courses. These outcomes may ultimately improve AP exams scores and yield associated benefits.

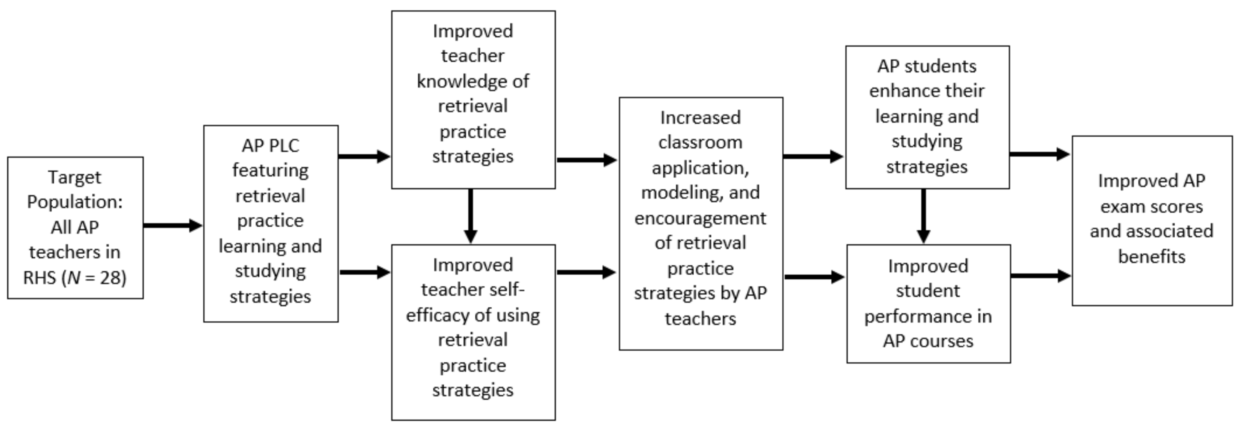

Figure 4.1. Theory of change for the AP PLC resulting in outcomes

Process Evaluation

This section discusses the process evaluation plan for the AP PLC, which begins with a presentation of the process evaluation question, followed by a discussion of the three process evaluation components to be evaluated: program implementation, participant responsiveness, and dose. This section then presents a justification for establishing attention toward iterative improvements of the AP PLC throughout its implementation, followed by a description of the indicators that will be used to measure the process evaluation components.

Research question 1. How did AP teachers describe their experience in the AP PLC? AP teacher experiences were measured by examining participants' perceptions of the meaningfulness of the AP PLC and their engagement in the AP PLC? A survey with Likert scale and open-ended items were used to collect data on participants' perceptions of these two constructs. The null hypothesis was that AP teachers' perceptions would not change over the course of the AP PLC. The alternative hypothesis was that AP teachers' perceptions would change over the course of the AP PLC.

Process evaluation components. This section discusses three components of the process evaluation plan: the AP PLC implementation, the participant responsiveness to the AP PLC, and the delivered dose of the AP PCL.

AP PLC implementation. The program implementation component allows researchers to identify strengths and shortcomings in the implementation of the program, acquire feedback about the process, record the process, and judge the program (Stufflebeam, 2003). The acquired feedback may describe the extent to which the intended activities are carried out and where adjustments to the plan may be necessary (Zhang et al., 2011).

To achieve effective program implementation (i.e., to be considered a school-wide AP program) the AP PLC should have at least 20 of the school's 28 AP teachers participate in the program. Further, at least 85% of participants should engage with the content covered in all 13 AP PLC sessions. Importantly, the new learning and collaborative time in the sessions should be perceived by participants as meaningful, in terms of strategies and practices that are applicable to teachers' AP classrooms. A wide range of data may be used to inform iterative adjustments to improve the AP PLC implementation, including qualitative measures and rating scales, as suggested by Sufflebeam (2003) and Zhang and colleagues (2011). As shown in the data collection matrix (Appendix H), both quantitative (i.e., Likert scale survey) and qualitative (i.e., open-ended survey questions; Appendix J) measures informed the AP PLC implementation by assessing participant perspectives of the meaningfulness of the AP PLC. The topics covered in the sessions were described in the activity outputs of the logic model (Appendix G) and AP teacher participation was presented in the participation outputs of the logic model. The outcomes shown in the logic model should be realized if teachers described the new learning and collaboration in the AP PLC as meaningful.

Participant responsiveness. The participant responsiveness component determines to what extent participants engaged with the activities and content of the program (Dusenbury, Brannigan, Falco, & Hansen, 2003). Teachers needed to be engaged and attentive in learning the new content in each session of the AP PLC so they could apply that new learning to collaboratively developed, ready-to-use lesson elements that incorporated retrieval practice strategies. Measuring participant responsiveness informed the evaluation of the AP PLC by indicating the level of active engagement beyond attendance.

AP teachers' level of engagement was measured qualitatively and quantitively, as shown in the data collection matrix (Appendix H). Qualitative measures included open-ended survey questions (Appendix I) and document analysis of products of the AP PLC (Appendix P), such as lesson elements that incorporate retrieval practice strategies. Analysis should suggest that AP teachers effectively develop lesson elements that incorporate retrieval practice and describe being actively engaged during the AP PLC. The quantitative measure was a researcher-created, Likert scale survey addressing the indicator of AP teachers' level of engagement in the AP PLC, which was considered with the qualitative measures to triangulate the findings. The outcomes shown in the logic model should be realized if the AP PLC effectively engaged AP teachers in cooperatively developing lesson components that incorporate retrieval practice.

Dose. The dose component describes the amount of an intervention that participants receive, which can be measured in terms of the number of sessions completed and the duration of the sessions (Dusenbury et al., 2003). Measuring the dose importantly identifies how much of the intervention was implemented to achieve the desired outcomes, or if the delivered dose was not enough to achieve the desired outcomes (Dusenbury et al., 2003).

In this study, AP PLC sessions was offered weekly for 13 consecutive weeks at the beginning of the school year. The number of sessions a teacher attended was recorded as a quantitative measure of dosage. The student researcher self-reported the number of sessions conducted, the duration of each session, and the attendance of each participant, as suggested by Dusenbury and colleagues (2003). Complete dose included attendance at the 90-minute initial session, followed by 12 30-minute sessions; between 10 to 20 minutes of each phase (i.e., new learning and collaboration) were required for all 30-minute sessions. Attendance for the sessions should be, on average, at least 85%. Aspects of the dose component are presented in the inputs and activity outputs in the logic model (Appendix G). The outcomes shown in the logic model should be realized if the AP PLC delivered the above specified dose.

Improvement science. The improvement science paradigm provides a framework for educational program providers to quickly learn and continually improve the implementation of programs (Bryk et al., 2015). Improvement science employs plan-do-study-act (PDSA) cycles that allow for adjustments to iteratively improve educational programs (Lewis, 2015).

The process evaluation of the AP PLC addressed all parts of the PDSA cycle. *Planning* the AP PLC was addressed by developing the evaluation questions, insofar as requiring close alignment between the evaluation questions and the planned outputs of the AP PLC. *Doing* the AP PLC was addressed by carefully implementing intervention components and measuring indicators, as described below. *Studying* the AP PLC was addressed by directly evaluating the program during and after implementation. *Acting* upon the AP PLC was addressed by using findings from the process evaluation to influence improvements throughout the duration of the program, which may also serve to inform future renditions of the program, as suggested by Stufflebeam (2003).

Formative examination of the process evaluation components informed iterative improvements of the AP PLC. As shown in the data collection matrix (Appendix H), data for the program implementation and participant responsiveness components were collected three times during the AP PLC (i.e., after weeks 4, 8, and 13 of the program). Further, a measurement of participant responsiveness (i.e., document analysis of lesson elements) and attendance of participants at the AP PLC sessions were gathered weekly. The regular interaction with participants provided opportunities for the researcher to collect program evaluation data, which indicated whether adjustments to the program were necessary (see Zhang et al., 2011). The data collected at these intervals informed the researcher: (a) if the AP PLC was being implementing meaningfully, (b) how well AP teachers were engaging in the AP PLC to collaboratively develop outputs, and (c) if the dose was being delivered as intended. If formative analysis of the program implementation component data after week four or eight suggested that teachers described the AP PLC as not meaningfully delivered, then adjustments could have been made to improve the AP PLC's meaningfulness (e.g., presented more compelling evidence that supports retrieval practice strategies). Similarly, if formative analysis of the participant responsiveness component data after week four or eight suggested that the AP PLC was not engaging teachers well in developing intended outputs, then adjustments could have been made to more actively engage participants (e.g., enhanced the modeling of strategies). Finally, if analysis of the dose of the AP PLC indicated the program was delivered less frequently or for less duration than intended—or if participant attendance was lower than expected—then additional inputs would have been acquired to improve the dose delivered (e.g., time for additional sessions).

Process evaluation indicators. This section discusses the two indicators that were used to answer the research question, which seeks to understand participants' experiences with the AP PLC. The two indicators were AP teachers' perceptions of the meaningfulness of the AP PLC and AP teachers' level of engagement in the AP PLC.

AP teachers' perceptions of the meaningfulness of the AP PLC. The first indicator, AP teachers' perceptions of the meaningfulness of the AP PLC, aligned with the program implementation component and aimed to measure whether the AP PLC was being implemented as intended. Participants' feedback was analyzed to determine if the new learning in the AP PLC meaningfully provided AP teachers with knowledge, skills, and collaborative resources to implement retrieval practice in their lessons.

The data source was all 22 AP teacher participants, who completed a Likert scale survey (Appendix I) to rate specific components of the AP PLC. The student researcher administered the same survey three times—after weeks 4, 8, and 13 of the 13-week the AP PLC program—to inform potential adjustments that may have iteratively improved implementation. Qualitative data were also collected on this survey, which included open-ended questions informed by the indicator. AP teachers' perception of the meaningfulness of the AP PLC aligned with the activities (e.g., new learning and modeling of retrieval practice strategies) in the logic model

(Appendix G). The outcomes represented in the logic model should be realized if AP teachers described the activities and outputs of the AP PLC as meaningful.

AP teachers' level of engagement in the AP PLC. The second indicator, AP teachers' level of engagement in the AP PLC, aligned with the participant responsiveness component. This indicator aimed to measure AP teacher engagement in the AP PLC through survey items and through evidence that teachers developed lesson elements that incorporated retrieval practice strategies. This indictor importantly gauged if the AP PLC effectively engaged teachers in the new learning and collaborative activities that supported AP teachers to develop retrieval practice strategies infused into their lesson plans. AP teachers' level of engagement in the AP PLC was observed from all 22 AP teacher participants.

Three data collection tools were used by the student researcher three times during the AP PLC; after weeks 4, 8, and 13 to support iterative improvements of future iterations of the AP PLC. A Likert scale survey gathered ratings of teacher engagement in the AP PLC through 11 items. Qualitative data were collected from open-ended survey questions targeting AP teacher engagement in the AP PLC. The document analysis was conducted by the student researcher by gathering outputs (e.g., lesson elements developed that incorporate retrieval practice) from one participant weekly. Document analysis of participants' lesson elements that featured retrieval practice informed evaluation of AP teacher engagement in the AP PLC; if teachers were actively engaged in the AP PLC, then they should have developed lesson components that effectively incorporated retrieval practice strategies. The outcomes represented in the logic model (Appendix G) should be realized if AP teachers indicated a high level of engagement in the AP PLC.

Outcome Evaluation

This section presents the design for examining the proximal outcomes of the AP PLC, which is presented in the data collection matrix (Appendix H). This section presents the outcome evaluation research questions, then discusses the mixed methods research design, the strengths and limitations of the design, and the implications for making adjustments to iteratively improve the AP PLC.

Research questions for the outcome evaluation. This section presents four research questions which were used to evaluate the outcomes of the AP PLC. This section also presents the measurement for each research question, along with a null and an alternative hypothesis for each research question.

Research question 2. To what extent did AP teachers' knowledge and self-efficacy of retrieval practice strategies increase in response to the AP PLC compared to a control group? Participants' knowledge and self-efficacy of retrieval practice strategies were measured pre- and post- the AP PLC by a Likert scale survey. Additionally, interviews conducted after the AP PLC further informed how participants' knowledge and self-efficacy increased in response to the AP PLC. The null hypothesis was that AP teachers' knowledge and self-efficacy of retrieval practice strategies would not change in response to the AP PLC. The alternative hypothesis was that AP teachers' knowledge and self-efficacy of retrieval practice strategies would increase in response to the AP PLC.

Research question 3. To what extent did AP teachers increase their use of retrieval practice strategies in their AP classes as a result of the AP PLC? AP teachers' use of retrieval practice strategies was measured weekly by a one-item survey inquiring about the frequency of implementing retrieval practice during the past week in AP teachers' classes. The null hypothesis was that AP teachers would demonstrate the same or decreased frequency of using retrieval practice strategies as the AP PLC progresses. The alternative hypothesis was that AP teachers would demonstrate increased frequency of using retrieval practice strategies as the AP PLC progresses.

Research question 4. What were AP teachers' perceptions of how well students were prepared for success in AP courses after the AP PLC compared to a control group? Student preparedness for success in AP courses was measured by AP teachers' perceptions that were reported pre- and post- the AP PLC by a survey. Additionally, interviews conducted after the AP PLC provided further insight into teachers' perceptions of how the AP PLC influenced student preparedness for AP coursework. The null hypothesis was that AP teachers would perceive the same or decreased student preparedness for AP coursework after the AP PLC. The alternative hypothesis was that AP teachers would perceive that students are better prepared for AP coursework after the AP PLC.

Research question 5. What was the difference between AP students' unit test scores before and after their teachers participated in the AP PLC compared to a control group? AP students' deidentified aggregated mean scores from select unit exams from December 2019 and September 2019 (i.e., both pre-intervention) and from December 2020 (i.e., post-intervention) were reported by AP teachers. The null hypothesis was that there was no difference between either pre-intervention aggregated mean unit exam scores and the post-intervention mean. The alternative hypothesis was that the post-intervention aggregated mean unit exam scores would be greater than either of the pre-intervention aggregated mean unit exam scores.

Outcome evaluation design. Three main philosophical paradigms underpin social science research: post-positivism, constructivism, and pragmatism (Johnson & Onwuegbuzie, 2004). The post-positivism paradigm is based on empiricism and has been traditionally associated with quantitative research (Mertens, 2018). In contrast, the constructivism paradigm is based on the notion that there is not one reality in the world to be discovered and measured; rather, reality is socially constructed differently by individuals and has been traditionally associated with qualitative research (Mertens, 2018). The pragmatism paradigm rejects the traditional dualism between post-positivism and constructivism and promotes a mixed methods research design—which includes both quantitative and qualitative strands—when both strands would best address the research purpose and answer the research question (Johnson & Onwuegbuzie, 2004). In this way, mixed methods research can use quantitative data to describe and explain what phenomena are occurring and can use qualitative data to explore—through thick, rich descriptions—why the observed phenomena may be occurring (Johnson & Onwuegbuzie, 2004). In the current mixed methods study evaluating the AP PLC intervention outcomes, the quantitative analysis measured, described, and explained the outcomes (see Appendix G) and the qualitative analysis provided a detailed description, through participants' voices, of why the observed outcomes may have occurred.

This study employed a convergent parallel mixed methods design, in which the quantitative and qualitative data were collected and analyzed concurrently and separately; then, the results were mixed during interpretation (see Creswell & Plano Clark, 2018). This convergent parallel design optimally targeted the goals of the research by obtaining different but complementary and validating strands of data (Creswell & Plano Clark, 2018). Additionally, this design was suitable for this study because it allowed the student researcher to gather different data concurrently, which accommodated the limited time available for collecting data. Further, the sample size of participants ($N = 35$) may have limited any potential causal inferences that could be made from the quantitative findings; thus, corroboration through thematic coding analysis of qualitative data triangulated the quantitative findings. This study employed a quasi-experimental design, which included a pre-test, a post-test, and a control group, but differed from a randomized control trial in that the sample selection and group assignments were not random (see Shadish et al., 2002). Specifically, the use of an untreated control group with dependent pre-test and post-test samples is called a nonequivalent comparison group design (Shadish et al., 2002). The control group permitted the measurement of impact the AP PLC had on the amount of the change observed in the outcomes that could be attributed to the AP PLC.

The study used purposive sampling, which is intentional selection of participants who possess a key trait or concept (Creswell & Plano Clark, 2018). Inclusion criteria for participants in the treatment group included full-time, certified AP teachers at the school that received the AP PLC. The qualitative sample of the treatment group was a subset of all the participants from the treatment group. The control group included AP teachers from a second school who conducted business as usual. In this QUAN + QUAL design (Creswell & Plano Clark, 2018), both the quantitative and qualitative strands were of equal status (i.e., both strands added insights to most or all research questions; Johnson, Onwuegbuzie, & Turner, 2007) because both quantitative and qualitative data (see data collection matrix; Appendix H) were used to describe and explore most of the research questions. The descriptive and inferential statistical analyses demonstrated the outcomes measured as possible changes in response to the AP PLC. Thematic coding of interview data corroborated the quantitative findings and supported descriptive explanations of how and why some quantitatively measured differences or changes occurred.

Additional data collected in this study included AP teachers' years of experience teaching and years of experience teaching an AP course. For both variables, more experienced teachers may have benefited less from the AP PLC than less experienced teachers, as their experience may have already provided them with knowledge and self-efficacy of retrieval practice strategies. Further, more experienced teachers may have more developed curricula compared to less experienced teachers, perhaps limiting the value of the collaborative component of the AP PLC for relatively experienced teachers. Contrastingly, more experienced teachers may have benefited more from the AP PLC if they have greater capacity to try new instructional techniques than less experienced teachers.

Strengths and limitations of the design. Four strengths of mixed methods research are presented in Table 4.1. Two specific strengths of the convergent parallel mixed method design are that the design is both intuitive for novice researchers, and it is efficient in regard to collecting data (Creswell & Plano Clark, 2018).

Table 4.1

Strengths of Mixed Method Design

Strength	Source
Provides more dynamic evidence for answering a research question than do either quantitative or qualitative alone	Creswell & Plano Clark, 2018
Provides the opportunity to draw from the strengths of both quantitative and qualitative methods while minimizing the weaknesses of both methods by combining both methods into one study	Johnson & Onwuegbuzie, 2004
Allows for reporting statistical findings from the quantitative strand that can be enriched and elaborated upon by participants' voice through the qualitative strand	Creswell & Plano Clark, 2018
Quantitative findings may allow for generalizations to a population; whereas, the qualitative observations may allow for an in-depth understanding	Creswell & Plano Clark, 2018

A limitation to mixed method research is that the required time and resources may exceed those needed to employ quantitative or qualitative methods alone (Creswell & Plano Clark, 2018); thus, the AP PLC was meticulously planned and efficiently completed to reserve adequate time for data analysis and interpretation. Three limitations specific to convergent parallel design are presented in Table 4.2, along with suggestions for how to minimize the limitations. Collectively, the strengths of employing a convergent parallel mixed method design for this study outweighed the limitations.

Table 4.2

Limitations to the Convergent Parallel Mixed Method Design and Considerations to Mitigate the Limitations

Limitation	Considerations to mitigate the limitation
The need to consider the consequences of different samples sizes for the quantitative data and qualitative data	The different sample sizes may not be a problem because the purpose of using both strands is to synthesize a complementary picture of the outcomes
The potential need to explain divergent data between the two strands if contradictions between the strands' data exists	If contradictions occur, that may lead to equally important findings and implications
The need to merge text-based data and numerical data—and associated results and implications—in a meaningful way	Resources (e.g., Creswell & Plano Clark, 2018) offer guidance for addressing this concern by using tools such as joint displays representing integration

Note. Adapted from Creswell and Plano Clark (2018).

A quasi-experimental design choice was compelling as it facilitated the potential for causal inferences, particularly compared to a nonexperimental design (see Shadish et al., 2002). The nonexperimental design was considered for this study. However, although a nonexperimental study could possibly support causal inferences, the control group in a quasi-experimental study offered a point of comparison for observed changes and reduced the likelihood of confounding variables being muddled with the intervention, which increased opportunities for causal inferences (see Shadish et al., 2002). An experimental design was also considered for this study; however, two concerns emerged. Randomized sampling within the population of AP teachers in the context under study would have resulted in smaller treatment and control groups of maximally 14 teachers per group. Additionally, due to the student researcher's employment in the school, relationships with teachers may have been compromised due to participants' random group assignment into the treatment or control group. Therefore, a quasi-experimental parallel convergent mixed method design was selected for the evaluation of the outcomes of the AP PLC.

The evaluation of the intervention provided insights about whether the AP PLC was correlated with changes observed in the outcomes. However, where correlations were observed, it may not have been possible to rule out other variables that may have influenced the outcomes (see Shadish et al., 2002). To make causal inferences about the AP PLC on the measured outcomes, it was important to identify and account for confounding variables, identify potential effects of these variables on the outcomes, and mitigate threats to the validity of inferences (see Shadish et al., 2002). Three threats to the validity of inferences for mixed methods research discussed by Creswell and Plano Clark (2018) that had implications for the evaluation of the AP PLC are presented in Table 4.3, along with considerations to minimize the threats.

Table 4.3

Threats to the Validity of Inferences for Mixed Methods Design and Considerations to Minimize the Threats

Threat to validity of inferences	Considerations to minimize the threat
Not using parallel constructs in the quantitative and qualitative data collection	Developing parallel research questions
Keeping quantitative and qualitative results separate	Using a convergent data integration strategy and weaving the results through narrative
Not resolving disconfirming results may pose a threat to validity	Using new analyses or other strategies to understand disconfirming results

Note. Adapted from Creswell and Plano Clark (2018).

Four threats to the validity of inferences for quasi-experimental studies are discussed by Shadish and colleagues (2002) that had implications for the evaluation of the AP PLC. These four threats to validity, along with definitions, considerations to mitigate the threats, and specific applications to the AP PLC are presented in Table 4.4.

Table 4.4

Threats to Validity of Inferences for Quasi-Experimental Design and Considerations to Mitigate

Threat to validity of inferences	Definition of the threat to validity	Considerations to mitigate the threat	Applications to the AP PLC
Selection bias	The treatment and control groups include different participants	Comparison of the pre-tests between the two groups	Compare pre-tests of treatment and control group using independent samples *t*-tests
		Matching for certain characteristics between the treatment and control groups	Breadth of the schools' AP Programs (i.e., how many AP courses are offered) and the schools' report cards and academic rankings from the state department of education's website
Selection-history	The possibility that local events that occur between the pre- and post-test affect one group more than the other	The student-researcher should maintain a log of any events that occur in either context that may influence the results of the study	Other professional development experienced at either the control or treatment school may influence the results of the AP PLC evaluation
Attrition bias	The possibility that a characteristic of participants causes them to drop out of the study differentially more in the treatment group	Using effective communication with participants, offering nominal incentives (e.g., snacks), establishing norms and expectations, and ensuring the intervention is relevant for teacher needs	AP teachers from the treatment group—who are subjected to higher demands than the control group through their participation in the AP PLC—may be more likely to drop out of the study. If AP teachers have certain characteristics, such as low motivation, then they may be more like to drop out of the study; thereby, leaving the treatment group with disproportionally more highly motivated teachers than the control group
Maturation	Changes that occur within the participants over time	The use of the control group may decrease the threat of maturation influencing the change measured in the outcomes, as both groups may mature similarly during the AP PLC	Comparing the change in outcomes measured from the treatment group to the control group may help determine the amount of change in the treatment group that was due to the AP PLC, not maturation

Note. Adapted from Shadish and colleagues (2002).

An a priori power analysis was performed using an alpha level of .05, a power level of .80, and an estimated effect size of 0.5, as informed from similar studies in the literature (e.g., JohnBull, Hardiman, & Rinne, 2013). The required sample size for an ANOVA with these parameters is 40 participants. The sample size for the study was 35 participants; therefore, analysis of qualitative data further helped examine the outcomes related to the research questions.

Improvement science. The outcome evaluation of the AP PLC primarily addressed the *study* part of the PDSA cycle. The *planning* of the AP PLC occurred from the Spring of 2020 through implementation. The *doing* of the AP PLC occurred from September 9, 2020 to December 16, 2020. The *studying* of the AP PLC was the part of the PDSA cycle that most aligned with the outcome evaluation. Following completion of the AP PLC, the outcomes measured shown in the logic model (Appendix G) were studied to gain an understanding of the effectiveness of the AP PLC in influencing the outcomes. The *acting* stage of the PDSA cycle may use the evaluation of the AP PLC to inform future renditions of the AP PLC. Based on evaluating the outcomes of the AP PLC, a similar intervention may be considered in other schools in the district, with non-AP teachers in the same school, or in other districts with similar student populations.

Potential future interventions may incorporate understandings gained from the outcome evaluation of the AP PLC; thereby, continuing future PDSA cycles. For example, if AP teachers did not increase knowledge of retrieval practice strategies in response to the AP PLC, future renditions of this intervention may increase the time resources devoted to new learning of the strategies and infuse more opportunities for active learning—as informed by best practices in professional learning literature (Darling-Hammond, Hyler, & Gardner, 2017)—into the AP PLC.

Additionally, if AP teachers did not increase self-efficacy of using retrieval practice strategies in their courses in response to the AP PLC, future renditions of this intervention may increase modeling of the strategies and coaching for participants to increase their self-efficacy of using the strategies. Maintaining a focus on future renditions of the AP PLC aligns with this suggestion from Christie, Inkelas, & Lemire (2017): improvement science may help to move away from the “adopt, attack, abandon” (p. 76) motif that has become too common among educational interventions and move towards an “adopt, adapt, and accomplish” (p. 76) motif that embraces improvement science principles for sustained enhancement of educational programs.

Method

This section describes the methodology for the AP PLC implementation and evaluation, which includes descriptions of the participants and instrumentation.

Participants

The participant population in the treatment group were certified teachers at RHS, a suburban/rural school in a Mideastern state. The participant population in the control group were certified teachers at a similarly matched high school (i.e., School E from the needs assessment presented in Chapter 2) in the district, who conducted business as usual. The matching criteria are summarized in Table 4.5.

Table 4.5

Matching Criteria Data for the Treatment and Control Groups

School	Overall ranking[a]	Academic achievement ranking[a]	Number of AP courses offered	Percent of students who received free or reduced meals in 2019
Control School – School E	70%	20.7	28	6
Treatment School – RHS	77%	20.9	26	13

[a]According to the state department of education publicly available school report card

All participants held a valid secondary education teaching certificate and were to teach at least one AP course during the 2020-2021 academic year. Inclusion criteria also required that participants were full-time faculty and were general education teachers (i.e., do not only hold a special education certificate). Participants included both males and females and represented a wide range of teaching experience. Recruitment occurred through an email sent to the participants' publicly available school email address. A standard script was sent to all eligible individuals (Appendix J). Exclusion criteria comprised individuals working in the school setting who do not hold a current and valid secondary teaching certificate, certified teachers who do not teach at least one AP course during the 2020-2021 academic year, and certified teachers who teach outside of RHS or the control school. The sampling procedure was purposive and included all AP teachers at RHS and the control school who volunteered to participate. Participants were deidentified by self-selecting code words entered in all instruments that represented each participant's pet name and first house number. Appropriate cautions and safeguards were implemented to ensure the privacy and protections of all participants.

Demographic data (Table 4.6) were collected from participants to aid in understanding what factors may moderate the outcomes of the AP PLC. Additionally, demographic data may indicate potential generalizability to other contexts where a program similar to the AP PLC may be suitable. Participants' demographic characteristics were self-reported in a separate survey to avoid the possibility of identifying individuals, and include race, gender, content area, years of teaching experience, and years of AP teaching experience.

Table 4.6

Demographics for the Treatment and Control Groups

Demographic characteristic		Treatment group (SD)	Control group (SD)
Gender	Female	64%	54%
	Male	36%	46%
Race	Asian	5%	0%
	White	95%	100%
Content Area	English	14%	15%
	Mathematics	14%	15%
	Social Studies	27%	23%
	Science	27%	31%
	World Languages	14%	8%
	Other	14%	8%
Mean Years of Experience Teaching		18.5 (6.4)	20.2 (4.5)
Mean Years of Experience Teaching AP		11.0 (5.7)	10.7 (5.9)

School-level characteristics data were also collected and described to inform generalizability of the AP PLC. Demographic data of the schools' student body and the number of AP courses the schools offer (Table 4.7) were obtained from a publicly available source and described to inform generalizability.

Table 4.7

Demographic Data for the Treatment and Control Schools

Demographic characteristic		Treatment school	Control school
Student Body Gender	Female	52%	48%
	Male	48%	52%
Student Body Race	Asian	3%	13%
	Black	3%	20%
	Hispanic	3%	10%
	2 or more races	3%	4%
	White	84%	53%
Number of Unique AP Courses Offered		26	28

Additionally, the AP PLC could be an effective program for high schools that robustly expanded AP enrollment without providing supports for new AP teachers and students new to advanced academic level coursework (a common phenomenon across the United States; Judson & Hobson, 2015; Kolluri, 2018).

Instrumentation

This section first presents the instrumentation used for the process evaluation. Then, the instrumentation used for the outcome evaluation is presented.

Instrumentation for process evaluation. This section presents the instrumentation used for the process evaluation. Specifically, this instrumentation includes a process evaluation survey, document analysis, attendance log, and demographic data survey.

Process evaluation survey. The Process Evaluation Survey (PES; Appendix I) was a 15-item electronic survey administered using Qualtrics, which included Likert scale ratings based on the Teacher Efficacy Scale (Gibson & Dembo, 1984). Four of the items are open-ended questions that sought to further understand participants' experiences with the AP PLC. These items measured the meaningfulness of the AP PLC, in terms of applicability to participants' AP classes and the level of participants' engagement in the AP PLC. The first administration of the PES included items that asked participants to report the potentially moderating variables of total years of teaching experience and years of experience teaching an AP course. Table 4.8 presents sample questions for the constructs measured.

Table 4.8

Summary of the PES

Process evaluation component	Measured construct	Likert scale sample item	Open-ended sample item
Implementation of the AP PLC	Meaningfulness of the AP PLC	I can apply the strategies to my AP course	Briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was meaningful for you?
Participant responsiveness to the AP PLC	Participants' level of engagement in the AP PLC	I was engaged in the presentation of research evidence for using retrieval practice strategies in the AP PLC	Briefly describe how the **collaborative activities** in the AP PLC were engaging for you?

Document analysis for process evaluation. A deliverable output of the AP PLC was lesson elements that incorporated retrieval practice created by participants each week in the AP PLC. These documents were submitted by participants via email and analyzed for evidence that the AP PLC effectively engaged participants in activities that supported developing lesson elements that incorporate retrieval practice. A priori codes for the document analysis are presented in Table 4.9.

Table 4.9

A Priori Codes for Qualitative Document Analysis

A priori codes	Definition
Retrieval practice	The process of actively calling information to mind rather than rereading it (Roediger & Butler, 2011)
Desirable difficulty	The presence of a considerable but manageable level of challenge while completing a task (Bjork & Bjork, 2014)
Spaced practice	Providing time to pass between practice may create a desirable difficulty for recall which enhances durable learning (Yan et al., 2017)
Delayed feedback	May permit some forgetting to occur; thereby, enhancing learning through incorporating a desirable level of difficulty (Yan et al., 2017)
Interleaved practice	Mixing different kinds of examples or problems during practice; as opposed to massed practice (Kang, 2017)
Flashcards	A low- or high-tech method of studying that incorporates retrieval practice via self-quizzing (Putnam et al., 2017)
Quizzing	Asking students to recall what they know during class before students look up the content in a source (Putnam et al., 2017)

Attendance log for the AP PLC. Attendance of participants at the AP PLC sessions was taken weekly. Maintaining a record of attendance allowed the dose of the AP PLC delivered to be measured.

Demographic data survey. The Demographic Data Survey (DDS; Appendix K), a three-item survey, was used to collect demographic information. Demographic data collected included race, gender, the specific AP course(s) currently taught.

Instrumentation for outcome evaluation. This section presents the measures that were used for the outcome evaluation. Specifically, this instrumentation included surveys, semi-structured interview protocols, and existing and current data (i.e., aggregated AP course unit exam scores).

Outcome evaluation survey for research questions 2 and 4. The Outcome Evaluation Survey (OES; Appendix L) was an electronic survey that was administered with Qualtrics, which included Likert scale items that sought to understand changes in participants' knowledge and self-efficacy of retrieval practice strategies, along with participants' perceptions of student preparedness for AP coursework. The OES was adapted from three existing surveys: (a) the Brain Targeted Teaching Efficacy Survey (Walker, 2016), (b) the Teacher Self-Efficacy Scale to Implement Self-Regulated Learning (De Smul, Heirweg, Van Keer, Devos, & Vandevelde, 2018), and (c) the Teacher Efficacy Scale (Gibson & Dembo, 1984). The OES includes three scales, each with multiple subscales, which are presented in Table 4.10, along with sample questions.

Table 4.10

Summary of the OES for Outcome Evaluation Research Questions 2 and 4

Measured construct (i.e., scale)	Subscale (number of items)	Sample question (knowledge questions were true or false; self-efficacy and perception questions were Likert scale)
Teacher knowledge of retrieval practice strategies	Definitional knowledge of retrieval practice strategies (15)	Repeatedly rereading information describes retrieval practice
	Knowledge of instructional activities that evoke retrieval practice in students (5)	Providing students with groups of similar problems during a unit review promotes more effective retrieval practice for students than mixing up types of problems during a unit review
	Knowledge of how retrieval practice appears in classroom activities (5)	At the end of a lesson, a teacher asks students to review content learned during the day's lesson by using their notes to answer summary questions
Teacher self-efficacy of retrieval practice strategies	Self-efficacy to employ instructional activities that promote retrieval practice (4)	I can create questions that promote retrieval practice to begin a lesson (i.e., warm-up, drill)
	Self-efficacy to employ instructional activities that optimize retrieval practice with complementary strategies (4)	I can develop class activities that space out the review of important content over time
	Self-efficacy to encourage students to use retrieval practice strategies when studying on their own (4)	I can model for students how to use retrieval practice strategies when studying on their own
AP teachers' perceptions of student preparedness for AP coursework	AP teachers' perceptions of AP students' repertoire of learning and studying strategies (5)	My AP students possess effective learning strategies
	AP teachers' perceptions of AP students' preparation for academic success (5)	My AP students are well prepared for AP coursework

Semi-structured interview for research questions 2 and 4. The semi-structured interview protocol (Appendix M) included researcher-created questions that aimed to measure teacher knowledge and self-efficacy of retrieval practice strategies, as well as teacher perceptions of student preparedness for AP coursework after learning retrieval practice strategies. The constructs measured and sample questions for the semi-structured interviews are presented in Table 4.11.

Table 4.11

Summary of the Semi-Structured Interview Protocol for Outcome Evaluation Research Questions 2 and 4

Construct measured (i.e., scale)	Sample question
Teacher knowledge of retrieval practice strategies	How has the AP PLC changed your understanding of what it looks like when students use retrieval practice strategies?
Teacher self-efficacy of retrieval practice strategies	How has the AP PLC changed your ability to prompt students' use retrieval practice strategies when studying on their own?
AP teachers' perceptions of student preparedness for AP coursework	How has the AP PLC prepared your AP students be better prepared for AP exams?

Frequency of use survey for research question 3. The Frequency of Use Survey (FUS; Appendix N) was a one-item electronic survey that included a quantitative item (i.e., the number of times I used retrieval practice strategies in my AP course during the past week was ___).

Aggregated student scores on select unit exams for research question 5. Participants reported existing and current data, specifically the aggregated mean scores from one unit exam for their AP course from each of the following months: December 2019, September 2020, and December 2020. There were two pre-intervention test scores reported (i.e., December 2019 and September 2020) and one post-intervention test score reported. The December 2019 pre-test score corresponds to the December 2020 post-test score because both tested student performance of the same content or unit of study. The September 2020 pre-test score corresponds to the December 2020 post-test score because both tested student performance following the same mode of instruction (i.e., virtual). This measure allows for a comparison in student outcomes before and after their teachers completed the AP PLC.

Procedure

This section presents an overview of the AP PLC intervention, followed by a description of the data collection and data analysis techniques.

AP PLC Intervention

The AP PLC was a 13-week long PL intervention led by the student researcher that incorporated new learning of retrieval practice strategies and collaborative opportunities for participants. The AP PLC included two main phases. The first phase was a 90-minute PL for AP teachers that occurred on September 9, 2020. The first phase introduced the rationale and goals of the AP PLC and established norms for the program. Additionally, the first phase addressed misconceptions participants may have had about optimal learning and studying strategies, as well as previewed retrieval practice strategies that build durable, flexible learning. All sessions of the AP PLC were video-recorded and those videos were made available to all participants, including any participants who were absent for particular sessions.

The second phase of the AP PLC consisted of weekly, 30-minute PL sessions that included new learning about retrieval practice strategies and collaborative opportunities for participants. The new learning occurred during approximately the first 15 minutes of each session and featured scaffolded information and evidence about effective retrieval practice strategies. During this new learning, the student researcher also modeled the application of the presented strategies. During approximately the last 15 minutes of each session, participants collaborated to enhance their application of retrieval practice strategies in their AP course. These collaborative activities were supported with coaching as the student researcher circulated among virtual breakout rooms. An intended outcome was for participants to leave each session with a lesson element that incorporated retrieval practice to be used in their AP course. The scope and sequence of the AP PLC, along with details of new learning and collaborative activities that occurred in each session, are presented in Table 4.12.

Table 4.12

Scope and Sequence of the AP PLC

	Phase 1: 90-minute PL for AP teachers	
September 9, 2020	Introduce rationale and goals for the AP PLC and establish norms Address misconceptions about optimal learning and studying strategies, as informed by SoL literature (Horvath, Lodge, & Hattie, 2017) Preview optimal strategies for building durable learning	
	Phase 2: 30-minute PL sessions for 12 consecutive weeks	
	First 15 minutes: New learning activities, modeling, and evidence	**Last 15 minutes: Collaboration and classroom applications**
September 16, 2020	Review misconceptions about learning and studying (Brown, Roediger, McDaniel, 2014) Introduce retrieval practice as a mechanism to enhance student performance (Roediger & Butler, 2011)	Teachers identify to what extent they currently use retrieval practice in their class Teachers identify places in existing lessons to incorporate retrieval practice
September 23, 2020	Explain evidence that supports retrieval practice as enhanced learning and studying strategies for durable learning (Brown, Roediger, McDaniel, 2014) Model basic classroom applications of effective retrieval practice	Teachers collaborate to enhance incorporation of retrieval practice (Using samples or ideas of lesson components that they bring)

September 30, 2020	Explain evidence that supports retrieval practice as enhanced learning and studying strategies for durable learning (Morano, 2019) Model basic classroom applications of effective retrieval practice	Teachers collaborate to enhance incorporation of retrieval practice (Using samples or ideas of lesson components that they bring)
October 7, 2020	Explain evidence that supports retrieval practice as enhanced learning and studying strategies for durable learning (Agarwal & Roediger, 2018) Model basic classroom applications of effective retrieval practice	Teachers collaborate to enhance incorporation of retrieval practice (Using samples or ideas of lesson components that they bring)
October 14, 2020	Explain nuanced and enhanced classroom applications (SPACING) of retrieval practice (Yan et al., 2017) Model SPACING classroom applications of effective retrieval practice	Teachers collaborate to enhance incorporation of SPACING in their retrieval practice applications (Using samples or ideas of lesson components that they bring)
October 21, 2020	Explain nuanced and enhanced classroom applications (INTERLEAVING) of retrieval practice (Kang, 2017) Model INTERLEAVING classroom applications of effective retrieval practice	Teachers collaborate to enhance incorporation of INTERLEAVING in their retrieval practice applications (Using samples or ideas of lesson components that they bring)
October 28, 2020	Explain nuanced and enhanced classroom applications (FEEDBACK) of retrieval practice (Yan et al., 2017) Model FEEDBACK classroom applications of effective retrieval practice	Teachers collaborate to enhance incorporation of FEEDBACK in their retrieval practice applications (Using samples or ideas of lesson components that they bring)
November 4, 2020	Explain nuanced and enhanced classroom applications (DESIRABLE DIFFICULTY) of retrieval practice (Bjork & Bjork, 2014) Model DESIREABLE DIFFICULTY classroom applications of effective retrieval practice	Teachers collaborate to enhance incorporation of DESIRABLE DIFFICULTY in their retrieval practice applications (Using samples or ideas of lesson components that they bring)

November 11, 2020	Model combining all elements to enhance effective retrieval practice (Brown, Roediger, McDaniel, 2014)	Teachers collaborate to combine all elements to enhance effective retrieval practice applications (Using samples or ideas of lesson components that they bring)
November 18, 2020	Explain and model techniques to help students effectively use retrieval practice when studying on their own (Agarwal & Roediger, 2018; Morano, 2019)	Teachers identify places in their lessons/curriculum where they can provide opportunities in class to model how to effectively use retrieval practice when studying on their own
December 9, 2020	Explain and model techniques to help students use retrieval practice when studying on their own (Firth et al., 2018)	Teachers collaborate and share positive and negative experiences of integrating retrieval practice to arrive at "best practices"
December 16, 2020	Review and summation	Teachers collaborate to develop a plan for how to sustain employing retrieval practice strategies moving forward

Data Collection

This section describes the general procedures for data collection, followed by descriptions of the process and outcome evaluation data sources. IRB approval was obtained from both the research institution and the school district under study. All electronic documents (i.e., survey data, document analysis data, attendance data, interview audio files, interview transcripts, and aggregated mean unit exam scores) are stored on a password-protected computer that only the student researcher has access to; all electronic data documents will be deleted in seven years.

Process evaluation data sources. This section presents how and when the four process evaluation data sources were collected: the PES, the document analysis, the attendance log, and the demographic data survey. Only participants in the treatment group contributed to the process evaluation data sources.

Process evaluation survey. The PES was administered using Qualtrics by the student researcher three times during the AP PLC: immediately after the sessions concluded during weeks 4, 8, and 13. Two items to collect moderating variable data (i.e., years of experience teaching overall and years of experience teaching an AP course) were included on the first administration of the PES.

Document analysis for process evaluation. The document analysis occurred weekly immediately after each Phase 2 session of the AP PLC. The student researcher randomly asked one participant to email a deliverable output (e.g., a ready-to-use lesson element that incorporate retrieval practice) that participants developed during the AP PLC.

Attendance log for the AP PLC. The number of participants who attend each AP PLC session was recorded by the student researcher. Participants must have either attended the full length of a session or watched the video recording of a session to qualify as being in attendance.

Demographic data survey. The DDS was administered using Qualtrics by the student researcher following the intervention. The DDS did not link to individual participants.

Outcome evaluation data sources. This section presents how and when the three outcome evaluation data sources were collected: the OES for research questions 2 and 4, the semi-structured interviews for research questions 2 and 4, the FUS for research question 3, and the aggregated mean student scores on select unit exams.

Outcome evaluation survey for research question 2 and 4. The OES was administered with Qualtrics by the student researcher, which was given to participants in both the control and treatment groups immediately prior to the AP PLC and immediately after the AP PLC.

Semi-structured interview for research questions 2 and 4. The semi-structured interviews were conducted by the student researcher individually with five randomly selected participants in the treatment group within one week after the AP PLC concluded. The inclusion criterion for these participants was that they completed the AP PLC; whereas, the exclusion criterion for these participants was that they did not complete the AP PLC. The interviews lasted approximately 15-20 minutes each and were audio-recorded and transcribed using Otter.ai speech to text software.

Frequency of use survey for research question 3. The FUS was administered with Qualtrics by the student researcher to all participants in the treatment group at the beginning of each AP PLC session in Phase 2. Participants who taught more than one AP course or more than one section of an AP course completed the FUS for only one specific AP class section.

Aggregated student scores on select unit exams for research question 5. Participants in the treatment and control groups reported aggregated, mean scores for AP course unit exams taken following the AP PLC (i.e., post-intervention; December 2020), the corresponding unit exam from the previous school year (i.e., pre-intervention; December 2019), and a pre-intervention unit exam from the beginning of the school year a virtual mode of instruction (i.e., September 2020).

Data Analysis

This section first describes the data analysis conducted for the process evaluation. Then, the data analysis conducted for the outcome evaluation data is described.

Process evaluation data sources. The process evaluation data were analyzed with both quantitative and qualitative data analyses. This section presents the data analysis for the PES, document analysis, attendance log, and the DDS.

Process evaluation survey. The PES—used to measure participants' experience in the AP PLC—was conducted three times during the AP PLC. In addition to descriptive statistics, repeated measures ANOVAs were used on these ordinal level data to examine participants' experience over three points in time (i.e., weeks 4, 8, and 13 of the AP PLC; independent variables) for each of the two subscales (i.e., meaningfulness of the AP PLC and teacher engagement in the AP PLC; dependent variables).

Qualitative questions in the survey were analyzed using thematic analysis (Braun & Clarke, 2006). Deductive coding used a priori codes (e.g., clear, meaningful, engaged, new learning, collaboration); then, inductive coding was conducted to allow new codes to emerge. Following immersion in the data, codes were refined and analysis revealed themes. The final codes and themes were checked for credibility through peer scrutiny (Shenton, 2004). A codebook was created (Appendix O) that indicated the final themes and codes, as well as definitions and example quotations for each code.

Document analysis for process evaluation. Qualitative analysis of the documents created by participants during the AP PLC was conducted using thematic analysis (Braun & Clarke, 2006). Deductive coding used a priori codes (Table 4.7); then, inductive coding was conducted to allow new codes to emerge. Following immersion in the data, codes were refined and analysis revealed themes. The final codes and themes were checked for credibility through peer scrutiny (Shenton, 2004). A codebook was created (Appendix P) that indicated the final themes and codes, as well as definitions and example quotations for each code.

Attendance log for the AP PLC. The attendance log was examined using descriptive statistics. This examination determined the dose of the AP PLC delivered to participants.

Demographic data survey. The demographic data were examined using descriptive statistics. This examination described the context of the AP PLC.

Outcome evaluation data sources. The outcome evaluation data were analyzed with both quantitative and qualitative data analyses. This section presents the data analysis for the OES, the semi-structured interviews, the FUS, and the aggregated student exam score data.

Outcome evaluation survey for research questions 2 and 4. The OES ordinal level data were analyzed with descriptive statistics and repeated measures ANOVA, which allowed for comparing two groups' data over repeated observations. This analysis was followed up with *t*-tests that compared the difference in pre and post means between the control and treatment groups for each of the subscales among the three dependent variables (i.e., AP teacher knowledge, self-efficacy, and perceptions, which are subscales in the OES).

Semi-structured interview for outcome evaluation research questions 2 and 4. The semi-structured interviews were transcribed and analyzed using thematic analysis (Braun & Clarke, 2006). Deductive coding used a priori codes (e.g., spacing, interleaving, quizzing); then, inductive coding revealed additional codes to emerge. Following immersion in the data, codes were refined and analysis revealed themes. The final codes and themes were checked for credibility through peer scrutiny (Shenton, 2004). A codebook was created (Appendix Q) that indicated the final themes and codes, as well as definitions and example quotations for each code.

Frequency of use survey for outcome evaluation research question 3. The FUS included one quantitative item that was analyzed with descriptive statistics and Pearson's correlation on this ratio level data to examine the change in participants' use of retrieval practice strategies over time throughout weeks 2 through 13 of the AP PLC. The independent variable was time, measured as week number of the intervention, and the dependent variable was the number of times participants reported using a retrieval practice strategy in their AP course during the previous week.

Aggregated student scores on select unit exams for research question 5. The aggregated mean unit exam scores were ratio level data examined using two independent samples *t*-tests. The first independent samples *t*-test compared the mean difference between aggregated student scores on a unit exam from December 2019 and from December 2020 between the control and treatment groups. This *t*-test allowed for detecting a difference in student performance before and after the intervention on the same course content, across two cohorts of students. A second independent samples *t*-test was conducted to account for the assumption not being met that the in-person mode of instruction would remain constant throughout the study. This second independent samples *t*-test compared the mean difference score between aggregated student scores on a unit exam from September 2020 and from December 2020 between the control and treatment groups. This *t*-test allowed for detecting a difference in student performance before and after the intervention using the same mode of instruction (i.e., virtual), in the same cohort of students.

Chapter 5: Results and Discussion

The salient findings from the process and outcome evaluations of the AP PLC intervention are presented and discussed in this chapter. First, a summary of the process of implementing the AP PLC is presented, including modifications that were made to the intervention plan. Then, the quantitative and qualitative findings from the process evaluation are discussed, followed by a discussion of the quantitative and qualitative findings from the outcome evaluation. Finally, conclusions, limitations, implications for practice, and future research are presented.

Process of Implementation

The AP PLC was implemented successfully according to the parameters established in Chapter 4. Prior to the AP PLC, successful implementation of the intervention was defined as 20 or more of the school's 28 AP teachers participation in the AP PLC and that the average participant attendance across all sessions was 85% or greater. Twenty-two of the school's 28 AP teachers participated in the AP PLC and the average participant attendance across all sessions was 96%. Participants who were absent for the initial presentation but viewed a video-recorded session and completed session activities after a particular AP PLC session were considered as present for that session. Additionally, demographic data of participants obtained from the Demographic Data Survey (DDS) were presented in Table 4.6 in Chapter 4.

The AP PLC was implemented as described in Chapter 4 with the exception of some modifications, which were informed by formative assessment of the implementation. First, a need emerged to build an anchor chart to collect the main ideas and strategies from the AP PLC in a simple depository. Thus, an online, collaborative concept map was gradually created by the AP PLC over the duration of the intervention that summarized the benefits of retrieval-based strategies, complementary strategies, and instructional practices that evoke retrieval. Second, a need emerged for participants to have a tangible collaborative workspace during the AP PLC. Thus, the AP PLC began using online, shared documents in virtual breakout rooms to enhance participation and consolidate ideas during the collaborative portions of sessions. Finally, a need emerged for participants to have resources to engage with outside of AP PLC sessions. Thus, podcasts and articles that discussed instructional applications of effective learning and studying strategies were shared with participants to engage with between some AP PLC sessions. Collectively, these modifications were implemented to enhance the AP PLC based on formative assessment.

Findings

This section presents the quantitative and qualitative findings from the process and outcome evaluations of the AP PLC intervention. The discussion of findings is organized by research question, which all address outcomes presented in the theory of change (Figure 4.1).

Process Evaluation Results and Discussion

The evaluation of the processes of the AP PLC intervention utilized both quantitative and qualitative measures to understand how participants described their experience in the AP PLC. The AP PLC implementation component of the process evaluation was measured by how participants perceived the meaningfulness of the AP PLC in terms of its applicability to their practice. The participant responsiveness component of the process evaluation was measured by participants' perception of their engagement in the AP PLC.

RQ1: How did teachers describe their experience in the AP PLC?

Quantitative data were collected and analyzed from the Likert-scale items of the Process Evaluation Survey (PES; Appendix I). Qualitative data were collected and analyzed from open-ended survey items on the PES and from document analysis of lesson components developed by participants. Process evaluation data were aggregated by two indicators: participants' perceptions of the meaningfulness of the AP PLC and participants' perception of their engagement in the AP PLC.

The quantitative portion of the PES included items with Likert-scale rankings from 1 (i.e., strongly disagree) to 6 (i.e., strongly agree). The entire PES and each of two subscales were tested using Cronbach's alpha to demonstrate internal consistency. The entire PES demonstrated reliability ($\alpha = .86$), as did the first subscale that included six items ($\alpha = .76$) measuring the meaningfulness of the AP PLC and the second subscale that included five items ($\alpha = .74$) measuring participant engagement in the AP PLC. Participants ($n = 22$) completed the PES three times: after weeks 4, 8, and 13 of the AP PLC. A composite mean for each subscale (i.e., meaningfulness and engagement) was computed and shown in Table 5.1.

Table 5.1

PES Mean Composite Subscores for Meaningfulness and Engagement Indicators

Indicator	Week 4 subscore[a] $n = 22$ (SD)	Week 8 subscore[a] $n = 22$ (SD)	Week 13 subscore[a] $n = 22$ (SD)
Meaningfulness composite	5.39 (0.41)	5.72 (0.24)	5.76 (0.30)
Engagement composite	5.46 (0.56)	5.67 (0.31)	5.73 (0.42)

[a]Likert scale ranged from 1 (strongly disagree) to 6 (strongly agree)

The mean composite subscores for both the meaningfulness and engagement indicators increased over the three times measured (see Table 5.1). Repeated measures ANOVA compared meaningfulness subscores (i.e., participants' perceptions of how applicable the strategies and instructional techniques learned in the AP PLC are for their AP class of the AP PLC) collected at weeks 4, 8, and 13 of the intervention. All assumptions for a repeated measures ANOVA were met for this analysis and for future applications of ANOVA in this study (i.e., a continuous scale dependent variable, categorical groups for the independent variable, no significant outliers, approximately normally distributed dependent variable data, and homogeneity of variances). ANOVA results indicated a main effect of the week number measured on the level of meaningfulness, $F(2,40) = 6.73$, $p = .003$. Repeated measures ANOVA compared participant engagement scores (i.e., the active engagement of participants during the AP PLC) collected at weeks 4, 8, and 13 of the intervention, $F(2,40) = 1.62$, $p = .21$. The mean subscores for meaningfulness and engagement over time during the AP PLC (see Table 5.1) suggested participants found the AP PLC sufficiently meaningful and engaging.

In addition to the increase in meaningfulness and engagement over time, the overall high mean rankings for meaningfulness (i.e., 5.39 to 5.76) and engagement (i.e., 5.46 to 5.73) implies that the participants perceived the strategies and instructional techniques learned in the AP PLC as applicable for their AP course and that participants felt actively engaged during the AP PLC sessions. The analysis of qualitative data from the PES helped reveal rich, descriptive details about how and why the AP PLC was meaningful and engaging for participants.

The qualitative portion of the PES included two open-ended items regarding the meaningfulness of each major portion of the AP PLC (i.e., the new learning and collaborative portions) for applicability in participants' AP classes. Additionally, the PES included two open-ended items regarding participants' engagement in each major portion of the AP PLC. Participants are identified by letter (e.g., Participant A) for qualitative data derived from the PES.

Meaningfulness of the new learning portion of the AP PLC. The PES included one open-ended item measuring the meaningfulness of the new learning portion of the AP PLC. The item was: briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was meaningful for you to use in your AP class. Thematic analysis (Braun & Clarke, 2006) of participant responses revealed five themes: *modeling*, *research*, *accessible*, *transformative*, and *limitations*. The final themes, frequency of themes, and definitions are summarized in Table 5.2 and the PES codebook is presented in Appendix O.

Table 5.2

Final Themes, Frequency, and Definitions for the Meaningfulness of the New Learning Portion of the AP PLC

Theme	Number of times the theme appeared during analysis	Definition
Modeling	17	The presenter's demonstration of a new concept or strategy by imitating that concept or strategies during instruction
Research	15	Evidence from research presented during the AP PLC that supports teachers' use of the strategies
Accessible	7	The ability for concepts or strategies to be readily obtained by participants due to the structure of the learning activities
Transformative	7	A fundamental change in teachers' perspectives on effective learning or teaching
Limitations	4	Factors that minimize the potential meaningfulness of the AP PLC

Participants frequently described the presenter's *modeling* of the effective instructional strategies that evoke students to use retrieval practice as a meaningful aspect of the new learning portion of the AP PLC. Participants often explained that the examples of instructional practices demonstrated in the AP PLC helped them draw connections to how they could integrate the practices in their own context. For example, Participant T explained, "I was able to see and hear about examples that I can try to parallel in my own subject area;" Participant I added, "I appreciated the real world examples that showed me how quickly and efficiently I could implement retrieval practice into my own content area." Further, some participants noticed the nuanced modeling of complementary strategies, such as spacing and interleaving practice, as

Participant B described, “[The presenter] did a great job at modeling the retrieval practices that we were learning about throughout the presentations. He also spaced out the information and came back to key ideas throughout the various presentations.” Collectively, effective *modeling* of the strategies was the most often cited meaningful aspect of the new learning portion of the AP PLC (see Table 5.2).

Participants often described the presentation of the *research* that supports the use of retrieval practice during instruction as a meaningful aspect of the new learning portion of the AP PLC. Participants frequently explained that the research supporting the use of retrieval practice strategies to help students build durable, flexible learning was compelling and meaningful for their context. For example, Participant F explained, “The science behind the practices helped me understand how to apply the technique to different subsets of students.” Additionally, Participant S stated, “It was helpful to gain a full understanding including the research behind the ideas presented.” Several participants explained that understanding how the strategies benefit students helped them see the value in incorporating the strategies in their courses; for example, Participant P stated, “Each session reminded us of the benefits [*sic*] and I liked that repitition [*sic*].” Collectively, presenting compelling *research* that supported the infusion of retrieval practice into instructional activities was an often-cited meaningful aspect of the new learning portion of the AP PLC.

Participants often described the *accessible* information in the new learning portion of the AP PLC as meaningful. Participants explained that characteristics of the AP PLC that made its content accessible helped make learning the strategies meaningful. For example, Participant G stated the AP PLC “was very well organized” and the content presented “was crystal clear. Easy to understand.” Further, Participant H explained, “[The presenter] presented clearly, answered questions and explained how each practice helped students to recall information long-term." Similarly, Participant I explained, "[The presenter] really broke the process down and the reasoning/explanation of the process and made it very easy to understand and use." Participant K echoed these sentiments; "The presentation of the content was clear, effective, and pragmatic in approach towards day-to-day teaching/learning." Collectively, ensuring the content in the AP PLC is *accessible* by organizing the activities well and clearly explaining concepts was an often-cited meaningful aspect of the new learning portion of the AP PLC.

Participants occasionally described their new learning in the AP PLC as *transformative*, with respect to their perceptions about effective learning and teaching practices, particularly regarding helping students learn how to study more effectively. Participants explained how the new learning activities in the AP PLC prompted them to transform the way they create optimal learning experiences through their teaching practices. For example, Participant K explained, "Retrieval practice has made me reconsider what "deep learning" and retention mean in practice." Participant O described a transformed instructional practice to promote retrieval in their students, as they stated, "I never really ask student [*sic*] to retrieve without looking at notes. I will start that at end of class now." Some participants indicated a recognition that transforming teaching practice to leverage retrieval strategies can be nuanced, as Participant J explains, "The presentation has prompted me to consider how and when I ask questions about particular topics, cumulatively-- be they [*sic*] within the same unit or from prior units of study." In addition to transformed perspectives on teaching practices, some participants described transformed perspectives on effective learning and studying strategies. For example, Participant P explained a transformed perspective that is closely connected to the equity goals of this study; "It helped me learn how to reevaluate the process of learning and reach a broader range of students in my class." Some participants described a transformed perspective on the importance of supporting students development of study skills, as Participant K stated, "Rather than telling students to just "study", [*sic*] I am discovering strategies to show them HOW to study for an assessment." Collectively, several participants expressed *transformative* perspectives of how they perceive effective learning and studying strategies, as well as teaching practices that support students to develop such skills.

Finally, some participants described the new learning in the AP PLC has having *limitations*. Those limitations were connected to specific content area AP courses and virtual learning. For example, Participant D explained, "My AP class is very much application-based. There is little vocabulary or similarly basic conceptual matter that would work with flash cards." Thus, it is possible that teachers and students in some content areas (e.g., performance art, AP Capstone) may stand to gain less from the AP PLC than teachers in other content areas. Additionally, participants expressed recognition that evoking and observing retrieval among students is substantially difficult in a virtual school setting, as Participant P referred to "The challenges that I will face in implementing retrieval practice [online]." Collectively, certain application-focused content areas and the ability to evoke and observe retrieval practice among students in virtual learning may be *limitations* to the meaningfulness of the AP PLC.

Meaningfulness of the collaborative portion of the AP PLC. The meaningfulness of the collaborative portion of the AP PLC was measured by one open-ended item in the PES and by document analysis of lesson elements produced by participants weekly in the AP PLC.

Meaningfulness measured by the PES. The PES included one open-ended item measuring the meaningfulness (i.e., participants' perceptions of how applicable the strategies and instructional techniques learned in the AP PLC were for their AP class) of the collaborative portion of the AP PLC. The item was: briefly describe how the **collaborative activities** in the AP PLC were meaningful for you to use in your AP class. Thematic analysis (Braun & Clarke, 2006) of this item revealed two themes: *sharing ideas* and *reflection*. The final themes, frequency of themes, and definitions are summarized in Table 5.3 and the PES codebook is presented in Appendix O.

Table 5.3

Final Themes, Frequency, and Definitions for the Meaningfulness of the Collaboration Portion of the AP PLC

Theme	Number of times the theme appeared during analysis	Definition
Sharing ideas	30	The collaborative exchange of instructional strategies and practices, which evoke retrieval in students, among participants
Reflection	8	Reconsideration of one's own practices informed by discussions of successes and challenges among colleagues

Nearly all participants explained *sharing ideas* among small groups of colleagues was the most meaningful aspect of the collaborative portion of the AP PLC. Participants demonstrated respect among colleagues and an eagerness to learn from each other. For example, Participant O explained, “It's always great to hear how my colleagues incorporate these strategies. Our job is often completed in isolation and I know that my colleagues are devoted professionals, so I appreciate their insights.” Similarly, Participant V stated, “Hearing how others implemented RP [retrieval practice] methods gave me new ideas to try.” Likewise, Participant E explained during the collaborative portion of the AP PLC, “Other teachers shared ideas that I can adapt for my own AP class.” Some participants explained that the sharing of ideas was particularly helpful because infusing retrieval practice in instruction was a new practice for some teachers;

Participant K explained "It is valuable to hear from other teachers about their trials in retrieval practice. This is a new concept to me and hearing feedback from practicing teachers in real time is very helpful." Collectively, nearly all participants explained how *sharing ideas* among colleagues was the most meaningful aspect of the collaborative portion of the AP PLC by supporting participants in applying the strategies to their own classes.

Interestingly, most participants preferred collaborating with colleagues from different disciplines, but that preference was not universal. For example, Participant M explained their preference for "Breakout rooms and sharing practices from different content areas." Participant N agreed: "It is extremely helpful to hear what other colleagues are doing in other disciplines…learning about the strategies used in different disciplines was meaningful." Similarly, Participant P stated, "Hearing from different courses and different departments how they implement practices and the challenges they face was insightful and helped me improve my strategies." In contrast, Participant F preferred collaborating with teachers of the same discipline, as they explained, "Input from other teachers of the same subject matter was the most useful…some were more meaningful than others--dicsussion [*sic*] with other teachers of the same subject were most meaningful and yielded the most useful ideas." Generally, participants found collaborating with interdisciplinary colleagues most meaningful.

The second theme that emerged was the *reflection* upon successes and challenges that participants found meaningful in the collaborative portion of the AP PLC. Participants often explained how the collaboration with colleagues supported reflection of successes and challenges leading to enhancing their own practice. For example, Participant I explained, "I appreciated hearing other teachers [*sic*] successes and failures because it allowed me to feel that I am not alone in my struggles and also garner new ideas for my own classroom." Participant I's reflection upon “successes and failures” was echoed in similar words among several participants, such as Participant K, who stated, “It is important to hear anecdotal successes and errors of retrieval practice to know how to best implement the practice.” Similarly, Participant O stated it is, “Always great to be able to share successes and concerns. The exchange of ideas about the concerns can solidify the validity of these practices.” Likewise, Participant V explained that, “Hearing colleague's [*sic*] individual teaching challenges and the strategies they use to solve them was helpful to me understanding my students and the context of my own course more thoroughly.” Further evidence of reflection was indicated by Participant B, who stated, “It was very helpful to talk to other teachers…about what was or was not working in their classes..” Collectively, many participants explained that *reflection* upon successes and challenges during the collaborative component of the AP PLC was meaningful and applicable for their practice.

Meaningfulness measured by document analysis of lesson elements. The meaningfulness of the collaborative portion of the AP PLC was also measured by document analysis of lesson elements, which incorporate retrieval strategies, developed by teachers during the collaborative portions AP PLC sessions and emailed to the student researcher. Thematic analysis (Braun & Clark, 2006) of the lesson elements revealed four themes that demonstrated the meaningfulness of the AP PLC collaboration: *retrieval practice*, *desirable difficulty*, *complementary strategies*, and *classroom applications*. The final themes and definitions are summarized in Table 5.4 and the document analysis codebook is presented in Appendix P. Participants are identified by “D” followed by a number (e.g., D1) for qualitative data derived from the document analysis.

Table 5.4

Final Themes and Definitions from Document Analysis of Lesson Elements Produced During the AP PLC

Theme	Definition
Retrieval practice	The process of actively calling information to mind rather than rereading it (Roediger & Butler, 2011)
Classroom applications	Low- or high- tech instructional practices that incorporate retrieval practice by requiring students to recall what they know from memory
Complementary strategies	The integration of allowing time to pass between practice (i.e., spacing) and mixing up problem types (i.e., interleaving), which may enhance durable, transferable learning (Yan et al., 2017)
Desirable difficulty	The presence of a considerable but manageable level of challenge while completing a task (Bjork & Bjork, 2014)

All lesson elements analyzed incorporated activities that promoted *retrieval practice* in students. Lesson elements demonstrating the application of retrieval strategies suggested the collaborative activities in the AP PLC were meaningful for AP teachers. Participant D5 created a regular weekly activity for their AP class which they creatively called "retrieval rendezvous." During this activity, the teacher would:

> Typically present some type of image that serves as a grounding element for memory retrieval. Sometimes it is a map. Other times it is a painting or picture of a temple or something. The idea is that in the future when the actively try to recall the information, the image will help bring them back to our retrieval session.

Many of the lesson elements analyzed demonstrated that only subtle changes to practice were needed to effectively integrate retrieval practice. For example, Participant D9 modified their questioning strategies to increase opportunities for retrieval practice among their students:

> I then pose a broad question: "Tell me everything you remember about the Ottoman military." I will exhaust responses and then ask a question that narrows the focus a bit, without giving away too much detail. And so [*sic*] after we exhaust all retrieval

> responses, we run through the PowerPoint, stopping at key locations to refresh their memories.

Similarly, Participant D8 coached their students to not refer to their book, notes, or online sources whenever they posted the phrase "retrieval practice" at the top of a drill or closure presentation slide. Additionally, Participant D11 instructed students to study key topics from old units of study for upcoming tests: "It was easy because all I had to do was copy some questions from old tests. But the key was getting them to study critical old topics and they even got to practice retrieving those again during the test." Collectively, all the analyzed lesson elements developed by participants during the AP PLC incorporated activities that promoted *retrieval practice* in students.

All lesson elements analyzed demonstrated direct *classroom applications* that evoked retrieval among students. The lesson elements developed included a range of classroom applications, suggesting the meaningfulness of the collaborative AP PLC. For example, Participant D16:

> Provided class time for everyone to make flashcards or a Quizlet. Then they shared the Quizlet link with me (or picture of flashcards), so I could give them feedback as needed. Then, the next day or so, I provided class time to practice with the flashcards/Quizlet. It has been motivational for them to use breakout rooms to quiz each other or play some of those Quizlet games together.

Participant D20 directed students to generate concept maps as a meaningful way to evoke their students to use retrieval. The teacher had students "make a concept map from memory rather than using their notes. Then, treat that as a first draft as they make a final draft using their notes to fill in the gaps." Participant D1 asked students to write down everything they could recall about a concept:

> I've found it very helpful and simple to have the kids brain dump everything down that they remember. Then, they go back in with a different color and add anything they forgot

> while using their notes. This created a nice little diagnostic for what they needed to focus on – so from there they made flashcards only [*sic*] what they forgot.

Collectively, the lesson elements developed by participants during the AP PLC demonstrated direct *classroom applications* of retrieval strategies.

Some lesson elements analyzed demonstrated *complementary strategies*, such as spacing, interleaving, and feedback, that may enhance the benefits of retrieval practice. The incorporation of these complementary strategies often required only modest changes to teachers' practice. For example, Participant D3 started providing chunked assignments as homework that required studying to encourage students to space out their studying over a period of days instead of cramming for a test:

> I normally give students several activities to do to prepare for a unit test. Make a mindmap, complete pages in a review book, complete chapter review questions, etc [*sic*]. I'm using the same review activities but making turn-ins with due dates scattered the week before a test instead of turning in everything on test day.

Participant D18 infused spacing and interleaving practice, as they "typically start class with 2 AP styles [*sic*] multiple choice questions from old units." Participant D12 interleaved practice for their students by restructuring their review material: "I used to have my review packets organized by type of problem. For our last unit, I copy pasted [*sic*] the problems to jumble it so kids didn't get too comfortable blindly repeating the same steps." Participant D19 provided effective feedback to their students after requiring retrieval: "I reassure them that partial answers are awesome, even if they are not super precise or detailed, or only partially accurate. Of course, I make sure to correct, in the end, any misconceptions, but only afterwards." Collectively, the lesson elements developed by participants during the AP PLC often infused *complementary strategies* that may enhance the benefits of retrieval practice.

Some lesson elements analyzed demonstrated purposefully increasing the *desirable difficulty* associated with practicing retrieval. These lesson elements demonstrated both teachers' and students' recognition of both the initial difficulty and benefits to learning experienced by learners when practicing retrieval. For example, Participant D15 changed their instructional practice by intentionally enhancing desirable difficulty to enhance students aural skills:

> Two times a week the AP Music Theory class conducts an aural skills activity called 'dictation.' Dictations are melodies that I play on the piano and students must write down the notes on the staff by ear. My standard practice has been to play, wait, and then give feedback as the answers come in. Instead of playing each example 3, 4, or 5 times in a row, I have tried playing the melody only once or twice. I have been encouraging students to 'make-up' or 'create a likely melody' for the answers that they believe are right, even if they are not confident. The results were shocking today. Using this practice resulted in BETTER pitch and rhythm accuracy than playing the melody twice as often. Increasing this difficulty for them is really paying off! I suppose giving students more time to process, pull info from their memory, and not giving-in to feeding the answers is obvious, but I was genuinely surprised at the accuracy students can generate. One of my students said, "I am shocked how well this works!"

Participant D21 explained how their AP students recognized the increased difficulty associated with retrieval practice but determined it was worth it to produce noticeably enhanced learning:

> At first, my students complained at not being able to use their notes during the warm-up and exit ticket. But we kept talking about it and they bought in. That was when THEY were the ones who noticed how well it works first. They said studying for quizzes is easier because they remember things better. Now they're just in the habit of making things harder on themselves because they know it works.

Collectively, several lesson elements developed by participants during the AP PLC demonstrated purposefully increasing the *desirable difficulty* during practicing retrieval.

Participant engagement in the new learning portion of the AP PLC. The PES included one open-ended item measuring participant engagement of the new learning portion of the AP PLC. The item was: briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was engaging for you. Thematic analysis (Braun & Clarke, 2006) of this item revealed four themes: Thematic analysis (Braun & Clarke, 2006) of this item revealed four themes:

interactive, *applicability*, *modeling*, and *research*. The final themes, frequency of themes, and definitions are summarized in Table 5.5 and the PES codebook is presented in Appendix O.

Table 5.5

Final Themes, Frequency, and Definitions for the Engagement in the New Learning Portion of the AP PLC

Theme	Number of times the theme appeared during analysis	Definition
Interactive	11	The structure of the AP PLC allowed for active learning and dynamic participation
Applicability	9	The characteristic of information and strategies that could readily be used in participants' AP courses
Modeling	8	The presenter's demonstration of a new concept or strategy by imitating that concept or strategies during instruction
Research	7	Evidence from research presented during the AP PLC that supports teachers' use of the strategies

Participants often reported the *interactive* nature of the AP PLC was engaging. Leveraging activities that promoted active learning, the new learning portion of the AP PLC was structured to involve dynamic participation of teachers. For example, Participant B explained that there was, "Lots of time for question and answer which helped me stay focused and engaged," and that "[The presenter] did a nice job at presenting information and asking questions throughout the presentation to keep me focused on the topic at hand." Similarly, Participant E stated, "There was opportunity to speak and type in the chat which helped me stay engaged;" a sentiment echoed by Participant V, who stated, "There was a good discussion through the chat and with mics." The interactive nature of the AP PLC was explained by Participant H, who stated, "The meetings were interactive—not just being talked at;" a notion similarly expressed by Participant P, who stated, "It required participation and was dynamic." Collectively, participants described being actively engaged in the AP PLC because of the *interactive* structure of the new learning portion.

Participants frequently explained the direct *applicability* of the content in the new learning portion of the AP PLC motivated them to be engaged. For example, Participant Q stated, "I [*sic*] allowed me to see specific examples that I could then apply to my content course [*sic*]." Similarly, Participant I explained, "The real class application piece got my attention and I appreciated that we tested the feature (student side) and got to see the teacher side." Likewise, Participant T "was able to envision using the practice in my own classes, and what that might look like in my different subject areas." Applicability of the strategies was also engaging for Participant F, who stated, "The leader's sharing of documents and examples of retrieval was effective in helping me develop my own retrieval ideas," and for Participant I, who stated, "The strategies were able to be adapted quickly for my own content and I am all about strategies that can help my students to be more successful!" Collectively, participants reported that the "clear examples" (Participant O) and "many good examples of applications" (Participant V) made the new learning portion of the AP PLC engaging because of its *applicability* across AP content areas.

Participants often reported the *modeling* of effective learning and studying strategies was an engaging aspect of the new learning portion of the AP PLC. For example, Participant B explained the "Quizzes live game kept me engaged and helped jogged my memory on our discussion topic." Similarly, Participant C stated, "Having us use the online game kept me interested and helped me see what it can look like for my students." More broadly, Participant L explained they were "Glad that [the presenter] used a different strategy each time, from the seemingly low tech that could be done in a traditional classroom, to high tech and online."

Participant V agreed that “Modeling retrieval practice acticities [*sic*] was engaging.” Collectively, participants found the *modeling* of a range of activities that promote retrieval to be engaging during the new learning portion of the AP PLC.

Finally, several participants reported that learning the *research* supporting the use of retrieval strategies to enhance student learning was engaging during the new learning portion of the AP PLC. For example, Participant A stated, “The presenter provided interesting data from the research in ways that are easy to follow visually.” Similarly, Participant P explained what they found engaging: “The sharing of retrieval practice research both in class and out of class situations. I am a data driven person.” Likewise, in response to this prompt, Participant K explained, “Hearing about definitive research is helpful!” Collectively, some participants found the *research* and evidence supporting the use of retrieval strategies during instruction engaging during the new learning portion of the AP PLC.

Participant engagement in the collaborative portion of the AP PLC. The PES included one open-ended item measuring participant engagement (i.e., the active engagement of participants during the AP PLC) of the collaborative of the AP PLC. The item was: briefly describe how the **collaboration** during AP PLC was engaging for you. Thematic analysis (Braun & Clarke, 2006) of this survey item revealed two themes: *active learning* and *enjoyment*. The final themes, frequency of use, and definitions are summarized in Table 5.6 and the PES codebook is presented in Appendix O.

Table 5.6

Final Themes, Frequency, and Definitions for the Engagement in the Collaborative Portion of the AP PLC

Theme	Number of times the theme appeared during analysis	Definition
Active learning	19	Learning activities in which participates directly interact in the learning process, as opposed to passively taking in information
Enjoyment	7	The process of taking pleasure in the activities

Participants often reported they found the *active learning* aspect of the collaborative portion of the AP PLC engaging. Active learning was represented by dialogue, completing collaborative documents, and collectively working toward shared goals. Participant R explained they found active learning aspects engaging because they "definitely pay more attention when I'm a member of a conversation rather than a passive listener." Other participants explained that "bouncing ideas off each other" (Participant O) was engaging. Additionally, Participant B explained that, "Collaborating on a shared document was helpful in starting discussion and giving us a visual to focus our thoughts and notes on." Participant P agreed; "I enjoyed completing collaborative documents with my peers and seeing how they viewed various components of the PLC." Participant I found volunteering as a notetaker helped themself stay focused. Participant B explained how working toward shared goals was engaging; "There were always guiding questions to focus on during the collaborative activities that helped keep teachers on task during our discussions." Finally, Participant P clearly summarized the statements made by several participants regarding the collaborative portion of the AP PLC; "It required participation and made me active in the learning." Collectively, participants found the *active learning* aspect of the collaboration with colleagues an engaging element of the AP PLC.

Participants frequently reported the *enjoyment* they derived from the collaborative portion of the AP PLC was engaging. For example, Participant G stated, "I enjoy workng [*sic*] in small groups in the breakout rooms." Likewise, Participant D explained, "It is good to talk to colleagues. I like to hear what they use in their own classes…I was always interested to hear what other teachers have been trying and what has been working well." Participant E shared a similar perspective; "I always enjoing [*sic*] talking with and learning from other teachers, this is somethings [*sic*] that has been sorely missing this year with virtual learning." While expressing their enjoyment in collaborating with colleagues during the AP PLC, Participant I also stated the value of collaboration; "I really like brainstorming and working with colleagues. Its [*sic*] how the best ideas are developed!" Collectively, participants found the *enjoyment* of collaborating with colleagues during the AP PLC engaging.

In summary, quantitative analysis revealed AP teachers rated their experience in both portions the AP PLC (i.e., new learning portion and collaborative portion) as meaningful and engaging. In fact, participants reported the AP PLC was increasingly meaningful and engaging over time (i.e., weeks 4, 8, and 13). The qualitative analysis revealed the presenter's modeling of strategies and the evidence presented from the research were the most frequently described meaningful components of the new learning portion of the AP PLC. AP teachers' opportunities to share ideas among colleagues and reflect on one's own practices through discussions with colleagues were the most frequently described meaningful components of the collaborative portion of the AP PLC. Additionally, document analysis of lesson elements developed by AP teachers during the AP PLC revealed participants successfully incorporated retrieval strategies, direct classroom applications, complementary strategies (e.g., spacing and interleaving practice), and desirable difficulty in their lessons. The interactive structure of the AP PLC, the applicability of information and strategies for their AP courses, the presenter's modeling of the strategies, and the evidence presented from the research were the most frequently described engaging components of the new learning portion of the intervention. The active learning and the enjoyment AP teachers took in the activities were the most frequently described engaging components of the collaborative portion of the AP PLC. Overall, quantitative and qualitative analyses revealed that AP teachers described their experience in both the new learning and collaborative portions of the AP PLC as meaningful and engaging.

Outcome Evaluation Results and Discussion

The evaluation of the outcomes of the AP PLC included an analysis of several proximal outcomes of the intervention. The outcomes evaluated include participants' knowledge of retrieval practice strategies, participants' self-efficacy for using retrieval practice strategies in their practice, participants' frequency of using retrieval practice strategies in their practice, participants' perceptions of their students' preparedness for AP coursework, and student performance on select course unit exams.

RQ2: To what extent did AP teachers' knowledge and self-efficacy of retrieval practice strategies increase in response to the AP PLC compared to a control group?

AP teachers completed the Outcome Evaluation Survey (OES) before and after participating in the AP PLC. The OES included scales measuring teacher knowledge of retrieval practice strategies and teacher self-efficacy for using retrieval practice strategies in their practice.

Teacher knowledge. The OES included 25 true/false items for the teacher knowledge scale. Table 5.7 shows the mean percent of correct responses for the three teacher knowledge subscales and the composite knowledge scale across the control (n = 13) and treatment (n = 22) groups.

Table 5.7

Participants' Mean Knowledge Scores of Retrieval Practice Strategies

Subscale/scale	Control group (n = 13) mean percent correct (SD)			Treatment group (n = 22) mean percent correct (SD)		
	Pre-test	Post-test	Mean difference (post – pre)	Pre-test	Post-test	Mean difference (post – pre)
First subscale: AP teachers' definitional knowledge of retrieval practice strategies	72.82 (11.37)	82.05 (11.35)	9.23	68.48 (14.86)	86.97 (3.84)	18.49
Second subscale: AP teachers' knowledge of instructional activities that evoke retrieval practice in students	73.85 (18.95)	66.15 (15.02)	-7.7	56.36 (14.65)	83.63 (10.02)	27.27
Third subscale: AP teachers' knowledge of how retrieval practice strategies appear in classroom activities	63.08 (17.97)	58.46 (19.08)	-4.62	59.09 (13.06)	91.82 (13.32)	32.73
Composite scale: AP teachers' knowledge of retrieval practice strategies	71.08 (10.73)	74.15 (9.18)	3.07	64.18 (11.28)	87.27 (3.83)	23.09

The gain in mean percent score was greater for the treatment than the control group for each of the three knowledge subscales (see Table 5.7). Notably, the composite mean percent score increased from the pre-test to the post-test for the control group by 3.07% and by 23.09% for the treatment group (see Table 5.7). Additionally, the composite standard deviation decreased from the pre-test to the post-test more for the treatment group (i.e., from 11.28 to 3.83) than for the control group (i.e., from 10.73 to 9.18), which indicated a greater decrease in variation in participants' knowledge in the treatment group. Finally, participants in the control and treatment groups did not begin with the same knowledge of effective retrieval strategies according to the pre-test subscores and composite score (see Table 5.7); thus, the analysis focused on examining the differences from pre to post between the control and treatment group.

The first knowledge subscale consisted of 15 items and measured AP teachers' definitional knowledge of retrieval practice strategies. Repeated measures ANOVA compared participants' knowledge subscores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 3.83$, $p = .059$. An independent samples t-test was used to reveal particular differences. All assumptions for independent samples t-tests were met (i.e., a continuous scale dependent variable, two categorical independent groups for the independent variable, independence of observations, no significant outliers, approximately normally distributed dependent variable data) except for homogeneity of variances, which was not expected for dichotomous data. The t-test compared the mean change in the first knowledge subscale for teachers in the treatment ($M = 2.73$, $SD = 2.33$) and control groups ($M = 1.38$, $SD = 1.80$); $t(33) = -4.04$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the first knowledge subscale than teachers in the control group.

The second knowledge subscale consisted of five items and measured teachers' knowledge of instructional activities that evoke retrieval practice in students. Repeated measures ANOVA compared participants' knowledge subscores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 30.55$, $p <$ 001. An independent samples t-test was used to reveal particular differences. All assumptions for independent samples t-tests were met, including homogeneity of variances. The t-test compared the mean change in the second knowledge subscale for teachers in the treatment ($M = 1.41$, $SD =$

0.73) and control groups (M = -0.39, SD = 1.19); $t(33) = -5.53$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the second knowledge subscale than teachers in the control group.

The third knowledge subscale consisted of five items and measured teachers' knowledge of how retrieval practice strategies appear in classroom activities. Repeated measures ANOVA compared participants' knowledge subscores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 28.9$, $p < .001$. An independent samples t-test was used to reveal particular differences. All assumptions for independent samples t-tests were met. The t-test compared the mean change in the third knowledge subscale for teachers in the treatment (M = 1.64, SD = 1.05) and control groups (M = -0.39, SD = 1.12); $t(33) = -5.37$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the third knowledge subscale than teachers in the control group.

Repeated measures ANOVA compared the composite knowledge scores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 26.7$, $p < .001$. An independent samples t-test was used to reveal particular differences. All assumptions for independent samples t-tests were met. The t-test compared the mean change in the composite knowledge scale for teachers in the treatment (M = 5.77, SD = 2.83) and control groups (M = 0.62, SD = 2.90); $t(33) = -5.16$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the composite knowledge scale than teachers in the control group.

The gains in teachers' knowledge across the three subscales and composite scores for the treatment group compared to the control group suggest the AP PLC successfully increased teachers' definitional and applicational knowledge of effective learning and studying strategies (see Table 5.8).

Table 5.8

Mean Change in Teachers' Knowledge of Effective Learning and Studying Strategies

Scale (number of items)	Control mean difference (SD)	Treatment mean difference (SD)	*t*-test
First subscale (15)	1.38 (1.80)	2.73 (2.33)	$t(33) = -4.04$, $p < .001$
Second subscale (5)	-0.39 (1.19)	1.41 (0.73)	$t(33) = -5.53$, $p < .001$
Third subscale (5)	-0.39 (1.12)	1.64 (1.05)	$t(33) = -5.37$, $p < .001$
Composite scale (25)	0.62 (2.90)	5.77 (2.83)	$t(33) = -5.16$, $p < .001$

The analysis of qualitative data from interviews with participants in the treatment group helped reveal rich, descriptive details about how and why the AP PLC supported this increased knowledge among teachers. Thematic analysis (Braun & Clarke, 2006) of interviews ($n = 5$) with participants following the AP PLC accessed teacher perceptions of how the AP PLC influenced their knowledge of effective learning and studying strategies featuring retrieval practice. The codebook for the interview data is presented in Appendix Q. Table 5.9 summarizes the two themes that emerged regarding how the AP PLC influenced teacher knowledge of the strategies: *intentional* and *complementary strategies*. Participants are identified by "I" followed by a number (e.g., I2) for qualitative data derived from the interviews.

Table 5.9

Themes for how the AP PLC Influenced Teachers' Knowledge of Retrieval Strategies

Theme	Definition
Intentional	The purposeful and conscientious effort AP teachers made to incorporate the strategies into their classes
Complementary strategies	The use of strategically spacing and interleaving retrieval practice among class activities to attempt to enhance student learning

Participants reported the AP PLC made the strategies readily identifiable so they could be more *intentional* using the strategies in practice, which may explain the increase in teachers' definitional knowledge of retrieval practice strategies that was observed in the quantitative findings. Participants described a vague general understanding of the strategies and modest implementation of the strategies prior to engaging in the AP PLC, but that the AP PLC "made me more cognizant of how to make [retrieval practice] more accessible for students in class, you know, more definitive, more concrete, and just more efficient" (Participant I2). Despite occasionally leveraging the previously nameless strategies in practice, participants described a benefit of having learned names and definitions for specific strategies. Participant I1 explained, "I had no idea what retrieval practice was before I started. So, it definitely taught me what it is and then I appreciated the differences between ways to use retrieval practice with my classes." Similarly, Participant I4 explained:

> I hadn't put a name to it. And when I started reading more about it, I realized okay well I've done some things like this in the past but now I feel like I'm more intentional with what I do with my planning, and with what I'm doing, and just really trying to make it for the kids, you know that active learning where they're, you know able to pull things from their brains that are there. And give them more opportunities for that. So, I guess the biggest thing for me is just being more intentional like I didn't know the terminology retrieval practice necessarily or spacing or durable learning or interleaving or anything like that but just having been able to read the articles that you posted. Also, and the podcasts, in addition to hearing what other people are doing was very beneficial.

Increasing teachers' knowledge of the names and definitions of effective learning and studying strategies helped teachers become more intentional in leveraging the strategies in their classes and more conscious about providing students with opportunities to enhance learning. Participant I3 explained:

> Before the PLC I had at least heard of the terms, but I had never really looked at them that deeply; like I kind of knew the basics of them. And I didn't really use retrieval after say the morning drill. And then, after the PLC, I definitely was a little bit more conscious about making sure that I was using them at least a couple times a week, even if it wasn't

> a ton every single class, but definitely using it more often in my AP classes and then even eventually in my other classes too, but definitely for my AP classes I think it was helpful.

Participant I4 explained how the increased knowledge of effective learning and studying strategies has allowed them to implement the strategies is focus and intent:

> I now am familiar with teaching practices such as interleaving spaced practice and retrieval which are all part of pedagogical practices I've done. But now that they are identifiable, I can actually focus on those specific teaching techniques, rather than just applying them to lesson plans, and having a vague understanding of what I'm doing and why I'm doing it. It gives specific targeted vocabulary to specific strategies that I can actually implement with focus and direction.

Collectively, participants reported how the AP PLC increased their definitional knowledge of effective learning and studying strategies, which translated to increased *intentional*, purposeful, and effective implementation of the strategies.

Participants reported the AP PLC increased their knowledge of *complementary strategies*, which may explain the increases in teachers' knowledge of instructional activities that invoke retrieval practice and knowledge of how retrieval practice appears in classroom activities that was observed in the quantitative findings. Participants described several general and specific complementary strategies that teachers can employ to promote retrieval in students. Participant I2 explained how they how leverage interleaving practice: "In the past, I would just always introduce a new phenomenon. Then, move onto the next. And now I am peppering in old phenomenon, to get them to think about that. And then, tying it into the new phenomenon." Further, Participant I2 explained how they optimize feedback for students: "Giving delays within the feedback, but trying to make sure that it's not too long, not too short to go back and revisit that content. A couple of days later works well." Additionally, Participant I2 demonstrated a strong understanding of the instructional actions that effectively evoking retrieval by students, by stating "Having them pull out what they know, filling in the gaps, as opposed to just leave it open ended." Participants also described several general and specific complementary strategies that appear in classroom activities. For example, Participant I3 explained how they:

> Encourag[e] the students to go through, and before they check all their notes, go through once, go through and almost like quiz themselves, giving them some different online, like quizzing techniques, or even just doing flashcards and flashcards are a little bit old school, but I think they're helpful, and being able to like quiz themselves very quickly to retrieve that knowledge.

Participant I3 demonstrated a knowledge of the subtle instructional behaviors required to evoke retrieval in the classroom activity of concept mapping by explaining:

> Concept maps or the mind maps, they found really helpful in their studying of just being able to like get out all the information that they can remember as quickly as possible, and then coming back later and kind of making all those connections.

Collectively, participants reported how the AP PLC increased their knowledge of how to evoke retrieval in students and how retrieval appears in classroom activities, which translated to increased and nuanced implementation of effective *complementary strategies*.

In summary, the quantitative analysis revealed that AP teachers' knowledge of retrieval practice strategies increased in response to the AP PLC compared to the control group. The qualitative analysis revealed that AP teachers described how the AP PLC increased their knowledge of the strategies by making the strategies readily identifiable so they could be more intentional and effective in using the strategies in their classes. Additionally, AP teachers described how the AP PLC increased their knowledge of complementary strategies that can be infused in their practice to optimize the benefits of retrieval strategies. Overall, AP teachers knowledge of retrieval practice strategies increased in response to the AP PLC.

Teacher self-efficacy. The OES included 12 Likert-scale items that measured teachers' self-efficacy for using retrieval strategies. The teacher self-efficacy scale from the OES and each of three subscales were tested using Cronbach's alpha to demonstrate internal consistency. The teacher self-efficacy scale from the OES demonstrated reliability ($\alpha = .91$), as did the first subscale that included 4-items (α = .87), the second subscale that included 4 items (α = .83), and the third subscale that included 4 items (α = .93). Exploratory factor analysis (see Table 5.10 for factor loadings) provided evidence that the four items in the first subscale (i.e., item 1 through item 4) measured one underlying construct, the four items in the second subscale (i.e., item 5 through item 8) measured a second underlying construct, and the four items in the third subscale (i.e., items 9 through items 12) measured a third underlying construct.

Table 5.10

Factor Loadings for Exploratory Factor Analysis of the Self-efficacy Scale

	Factor and subscale		
Item number	1	2	3
Item 1	.85		
Item 2	.86		
Item 3	.79		
Item 4	.51		
Item 5		.72	
Item 6		.61	
Item 7		.70	
Item 8		.66	
Item 9			.69
Item 10			.77
Item 11			.93
Item 12			.85

Table 5.11 shows the mean Likert-scale rankings of 1 (i.e., strongly disagree) to 6 (i.e., strongly agree) for the three self-efficacy subscales and the composite self-efficacy scale across the control (n = 13) and treatment (n = 22) groups.

Table 5.11

Participants' Mean Self-Efficacy Ratings for Using Retrieval Practice Strategies

Subscale/scale	Control group mean rating (SD)			Treatment group mean rating (SD)		
	Pre-test[a]	Post-test[a]	Mean difference (post – pre)	Pre-test[a]	Post-test[a]	Mean difference (post – pre)
First subscale: AP teachers' self-efficacy to employ instructional strategies that promote retrieval (Items 1-4)	5.15 (0.74)	5.13 (0.67)	0.02 (0.26)	4.83 (0.89)	5.59 (0.34)	0.76 (0.78)
Second subscale: AP teachers' self-efficacy to employ instructional strategies that optimize retrieval with complementary strategies (Items 5-8)	5.29 (0.74)	5.17 (0.84)	-0.12 (0.49)	4.52 (0.72)	5.17 (0.56)	0.65 (0.72)
Third subscale: AP teachers' self-efficacy to encourage students to use retrieval practice when studying on their own (Items 9-12)	4.69 (0.66)	4.88 (0.65)	0.19 (0.44)	4.09 (1.13)	5.52 (0.47)	1.43 (1.13)
Composite scale: AP teachers' self-efficacy for using retrieval practice strategies	5.05 (0.54)	5.03 (0.56)	-0.02 (0.23)	4.48 (0.76)	5.37 (0.41)	0.89 (0.72)

[a]Likert scale ranged from 1 (strongly disagree) to 6 (strongly agree)

The mean self-efficacy ratings increased for the treatment group across all three subscales; whereas, for the control group, the mean self-efficacy ratings decreased for the first and second subscales and increased for the third subscale (see Table 5.11). Notably, from the pre-test to the post-test, the composite mean Likert-scale self-efficacy score decreased by 0.02 for the control group and increased by 0.89 for the treatment group. Additionally, from pre-test to post-test, the composite standard deviation decreased for the treatment group (from 0.76 to 0.41)—which indicated a decrease in variation in participants' self-efficacy in the treatment group—compared to an increased composite standard deviation for the control group (from 0.54

to 0.56). Finally, participants in the control and treatment groups did not begin with the same self-efficacy for using retrieval strategies according to the pre-test subscores and composite score (see Table 5.11); thus, the analysis focused on examining the differences from pre to post between the control and treatment group.

The first self-efficacy subscale measured AP teachers' self-efficacy to employ instructional strategies that promote retrieval. Repeated measures ANOVA compared self-efficacy scores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 12.2$, $p < .001$. An independent samples *t*-test was used to reveal particular differences. All assumptions for independent samples *t*-tests were met. The *t*-test compared the mean change in the first self-efficacy subscale for teachers in the treatment (M = 0.76, SD = 0.78) and control groups (M = -0.02, SD = 0.26); $t(33) = -3.49$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the first self-efficacy subscale than teachers in the control group.

The second self-efficacy subscale measured AP teachers' self-efficacy to employ instructional strategies that optimize retrieval with complementary strategies. Repeated measures ANOVA compared self-efficacy scores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 11.39$, $p = .002$. An independent samples *t*-test was used to reveal particular differences. All assumptions for independent samples *t*-tests were met. The *t*-test compared the mean change in the second self-efficacy subscale for teachers in the treatment (M = 0.65, SD = 0.72) and control groups (M = -0.12, SD = 0.49); $t(33) = -3.38$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the second self-efficacy subscale than teachers in the control group.

The third self-efficacy subscale measured teachers' self-efficacy to encourage students to use retrieval practice when studying on their own. Repeated measures ANOVA compared self-efficacy scores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 14.3$, $p < .001$. An independent samples *t*-test was used to reveal particular differences. All assumptions for independent samples *t*-tests were met. The *t*-test compared the mean change in the third self-efficacy subscale for teachers in the treatment (M = 1.43, SD = 1.13) and control groups (M = 0.19, SD = 0.44); $t(33) = -3.78$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the third self-efficacy subscale than teachers in the control group.

Repeated measures ANOVA compared the composite self-efficacy scores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 19.4$, $p < .001$. An independent samples *t*-test was used to reveal particular differences. All assumptions for independent samples *t*-tests were met. The *t*-test compared the mean change in the composite self-efficacy scale for teachers in the treatment (M = 0.89, SD = 0.72) and control groups (M = -0.02, SD = 0.23); $t(33) = -4.40$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the composite self-efficacy scale than teachers in the control group.

The gains in teachers' self-efficacy across the three subscales and composite scale for the treatment group compared to the control group suggest the AP PLC successfully increased teachers' self-efficacy to employ effective learning and studying strategies (see Table 5.12).

Table 5.12

Mean Change in Teachers' Self-Efficacy for Using Effective Learning and Studying Strategies

Scale (number of items)	Control mean difference (SD)	Treatment mean difference (SD)	*t*-test
First subscale (4)	-0.02 (0.26)	0.76 (0.78)	$t(33) = -3.49, p < .001$
Second subscale (4)	-0.12 (0.49)	0.65 (0.72)	$t(33) = -3.38, p < .001$
Third subscale 3 (4)	0.19 (0.44)	1.43 (1.13)	$t(33) = -3.78, p < .001$
Composite scale (12)	0.02 (0.23)	0.89 (0.72)	$t(33) = -4.40, p < .001$

The analysis of qualitative data from interviews with participants in the treatment group helped reveal rich, descriptive details about how and why the AP PLC supported this increased self-efficacy among teachers. Thematic analysis (Braun & Clarke, 2006) of interviews (n = 5) with participants following the AP PLC illuminated teacher perceptions of how the AP PLC influenced their self-efficacy of using effective learning and studying strategies featuring retrieval practice. The codebook for the interview data is presented in Appendix Q. Table 5.13 summarizes the three themes that emerged regarding how the AP PLC influenced teacher self-efficacy for using the strategies: *subtle practice changes*, *specific activities*, and *student studying*.

Table 5.13

Themes for how the AP PLC Influenced Teachers' Self-Efficacy for Using Retrieval Strategies

Theme	Definition
Subtle practice changes	The modest modifications to teachers instructional behavior to incorporate retrieval strategies
Specific activities	A range of low-tech and high-tech classroom activities that promote students to practice retrieval
Student studying	The act of students using retrieval strategies when studying on their own

Participants reported the AP PLC helped them make *subtle practice changes* that could leverage the benefits of retrieval, which may explain the increase in participants' self-efficacy to employ instructional strategies that promote retrieval practice that was observed in the quantitative data. Participant I4 explained how they were able to make subtle changes to their practice to effectively promote retrieval:

> I've been doing a lot of that like don't look at your notes yet. And we do that for vocabulary quizzes. Some of the grammar things I'm even using that in my ninth-grade class don't look at your notes just, you know, jot down what you think it is and then we can talk about it and go back.

Participant 1 explained how increases in their self-efficacy of using subtle reminders to students and specific phrasing of questions and directions can readily leverage the benefits of retrieval:

> Searching for ways, and like spots within class to implement some of the strategies that we talked about, and even just changing my phrasing so like when I'm asking a question, if I hear a long pause, or I'm not getting any responses, I'm reminding students you know don't go right to your notes, but like see, even if it's like not quite right, see what you come up with to answer this question to kind of like unpack the information and try to like pull it back out of their brains as opposed to just quickly them going to notes or Google.

Participant I5 explained how increases in their self-efficacy for providing opportunities for desirable difficulty can enhance student learning:

> What the PLC and retrieval practices have encouraged me to do in my classes, is to make them suffer through it a little bit more, but not in literal terms, not suffering, but make them endure a little bit more thinking and making them work for it. And we talked a little bit, well a lot, about durable learning, and how in order for learning to be more enduring and durable, we have to give them that those obstacles and not just give them all the information up front right away.

Further, participants explained they were comfortable incorporating the retrieval strategies in their classes, as Participant I1 explained, "I really like professional development that's quickly implementable. So, I really appreciated like how, like all the strategies presented make it easy to incorporate it into my classes." Collectively, participants reported how the AP PLC increased their self-efficacy for employing instructional strategies that promoted retrieval by being able to leverage *subtle practice changes* to their instructional practices.

Participants reported how the AP PLC helped them incorporate *specific activities* in the classroom, which may explain the increase in participants' self-efficacy to employ instructional strategies that optimize the benefits of retrieval with complementary strategies that was observed in the quantitative data. Participants explained several classroom activities that they became increasingly confident using, which existed along a continuum of technology levels. Participant I3 explained how they became confident using some relatively high-tech computer application that was modeled and practiced during the AP PLC as a form of low-stakes retrieval:

> Quizalize is like a version of Kahoot!, but they do it themselves and they have like 10 seconds 20 seconds to answer questions. And it's kind of like a game review for them, and they really didn't have the chance to look up questions because it's so quickly done, and they really liked it and then it kind of gave them an analysis afterwards of the things they got right and things they got wrong. And it was a nice, kind of like low stakes review where were seeing the results that weren't on blast for their class to see, but they were able to kind of see their [individual] results.

Participant I2 described some relatively low-tech applications (i.e., think-pair-shares and cumulative questions) they became increasingly comfortable using throughout the AP PLC:

> I've been using think-pair shares a lot just a quick like okay what are you thinking what do you remember, without looking at your notes. I think it's a good kind of review for them throughout the semester. I also started using like cumulative questions to things over the course…and incorporate those and telling them to go back and make those connections to previous units.

Similarly, Participant I4 explained additional relatively low-tech specific activities (i.e., warmups, self-assessments, and reflections) that leverage complementary strategies to optimize the benefits of retrieval:

> I really am trying to incorporate as much as I can into warmups practice where there's, you know, they're not feeling like oh if I mess this up it's really going to impact my grade. I'm definitely taking things from what other teachers have said, you know in our

> small groups where we're collaborating, and I'm applying it to my classes. Like giving more self-assessments, more reflections.

Collectively, participants reported how the AP PLC increased their self-efficacy for employing instructional strategies that optimized the benefits of retrieval by incorporating various *specific activities* among their instructional practices

Participants reported how the AP PLC helped them support *student studying*, which may explain the increase in participants' self-efficacy to encourage students to use retrieval practice when studying on their own that was observed in the quantitative data. Participants explained specific study strategies they modeled for students and how they provided opportunities for students to practice and develop such skills. For example, Participant I1 explained:

> I'm like reminding them as they're studying to, for example, like they're working on an outline, or a study guide, do everything you can first in one color, without any of your notes, and then see where the blanks are see switch colors kind of see where you still need work. Use your notes, go through, and then kind of like you know kind of where your weak spots are and try to like move forward. And like I feel like they've been doing that more, I'm seeing more study guides filled in the initial color, and like less, I had to look at my notes.

Participant I2 explained how their increased comfort with teaching studying strategies translated into more opportunities for students to develop studying skills: "If they were attentive during class, they definitely came away with better strategies for studying; I taught that more than I've ever taught before." Participant I3 described how their confidence in teaching study strategies that leverage retrieval has increased and positively influenced students:

> My confidence [for helping students learn how to study on their own has] definitely increased. Before it was always kind of struggle, this is only my second year teaching AP, and I struggled trying to teach them how to study. I think it's hard to give them the skills to learn. Giving them some of these different like techniques has been really helpful for me to help them.

Collectively, participants reported how the AP PLC increased their self-efficacy for encouraging students to use retrieval when studying on their own by modeling effective study strategies for participants and providing participants opportunities to practice the strategies during the AP PLC, which supported effective *student studying*.

In summary, the quantitative analysis revealed that AP teachers' self-efficacy of using retrieval practice strategies significantly increased in response to the AP PLC compared to the control group. The qualitative analysis revealed that AP teachers described how the AP PLC supported them in making subtle practice changes that leveraged the benefits of retrieval strategies for their students. Additionally, AP teachers described how the AP PLC helped them learn and incorporate specific activities in their AP classes that promoted retrieval in their students. Finally, AP teachers described how the AP PLC helped them learn how to support their students use of effective studying strategies when studying on their own. Overall, AP teachers' self-efficacy regarding using retrieval practice strategies increased in response to the AP PLC.

RQ3: To what extent did AP teachers increase their use of retrieval practice strategies in their AP classes as a result of the AP PLC?

Participants reported the number of times they used retrieval practice strategies in one AP class during the previous week at the beginning of AP PLC sessions 2 through 13. Table 5.14 shows the mean and median number of times that participants reported using retrieval practice strategies in their AP class during the past week.

Table 5.14

Participants' Frequency of Using Retrieval Practice Strategies Over Time During the AP PLC

Week number	Mean number of reported uses of a retrieval practice strategy during the past week (n = 22; SD)	Median number of reported uses of a retrieval practice strategy during the past week (n = 22; IQR)
2	0.91 (0.87)	1 (1)
3	3.41 (2.42)	2.5 (2.5)
4	3.09 (2.39)	2.5 (2)
5	3.32 (2.34)	3 (2)
6	3.27 (2.37)	3 (2)
7	3.27 (1.98)	3 (2)
8	4.45 (4.15)	3 (3.75)
9	3.86 (2.17)	4 (3)
10	5.27 (5.88)	4 (2.75)
11	4.41 (2.91)	4 (2.75)
12	4.68 (2.97)	5 (2.75)
13	5.50 (3.66)	4.5 (5.5)

The number of reported uses of retrieval strategies in AP courses generally increased over the duration of the AP PLC (see Table 5.14). Specifically, the mean number of reported uses of a retrieval strategy increased from week 2 ($\bar{x}$ = 0.91, *SD* = 0.87) to week 13 ($\bar{x}$ = 5.50, *SD* = 3.66). Figure 5.1 illustrates the increase in mean uses of the strategies reported over the duration of the intervention.

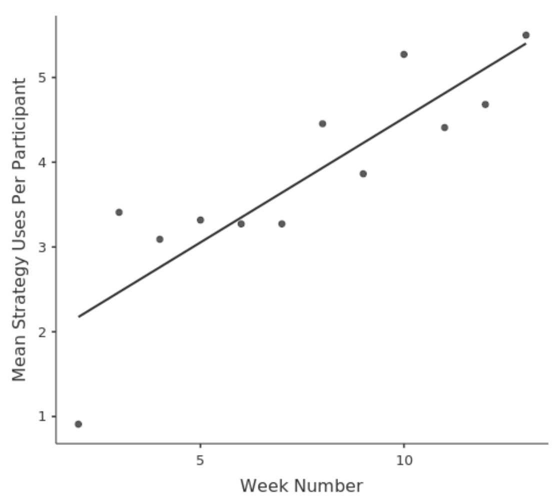

Figure 5.1 Mean number of reported retrieval strategies used per week during the AP PLC

A Pearson correlation measured the relationship between the time, in weeks, of the AP PLC and the mean number of strategy uses reported by participants. All assumptions for a Person correlation were met (i.e., both continuous level variables, related pairs of variables, no outliers, approximately normally distributed variables, and a linear relationship between the variables). There was a strong, positive, significant correlation between time and mean strategy uses (r = .865, n = 22, p < .001). In summary, participants reported increased uses of the retrieval strategies in their AP courses over the duration of the intervention. Thus, teachers significantly increased their use of retrieval practice strategies in their AP classes as a result of the AP PLC.

RQ4: What are AP teachers' perceptions of how well students are prepared for success in AP courses after the AP PLC compared to a control group?

The OES included 10 Likert-scale items that measured teachers' perceptions of how well students are prepared for success in AP courses. The entire teachers' perceptions scale from the OES and each of the two subscales were tested using Cronbach's alpha to demonstrate internal consistency. The entire perceptions of preparedness scale from the OES demonstrated reliability (α = .93), as did the first subscale that included 4 items (α = .94) and the second subscale that included 6 items (α = .88). Initially, item 5 was intended to be included in the first subscale. However, exploratory factor analysis provided evidence that the first four items loaded on one construct and the last six items loaded onto a second construct. Upon further scrutiny, the language of item 5 was noticeably different from the first four items and the content of item 5 aligned closer to the second subscale than the first subscale (see Appendix L). Therefore, items 1 through 4 comprised the first subscale and items 5 through 10 comprised the second subscale. Table 5.15 provides the factor loadings for the items in terms of two underlying factors.

Table 5.15

Factor Loadings for Exploratory Factor Analysis of the Perceptions of Preparedness Scale

Item number	Factor and subscale 1	2
Item 1	.91	
Item 2	.68	
Item 3	.85	
Item 4	.96	
Item 5		.44
Item 6		.78
Item 7		.47
Item 8		.70
Item 9		.72
Item 10		.94

Table 5.16 shows the mean Likert-scale ratings from 1 (i.e., strongly disagree) to 6 (i.e., strongly agree) for the two teacher perceptions of preparedness subscales and the composite teacher perceptions of preparedness scale across the control (n = 13) and treatment (n = 22) groups.

Table 5.16

Participants' Mean Ratings for Perceptions of Students' Preparedness for Success in AP Courses

Subscale/scale	Control group mean rating (SD)			Treatment group mean rating (SD)		
	Pre-test[a]	Post-test[a]	Mean difference (post – pre)	Pre-test[a]	Post-test[a]	Mean difference (post – pre)
First subscale: AP teachers' perceptions of students' repertoire of effective learning and studying strategies (Items 1-4)	4.58 (0.48)	4.55 (0.49)	-0.03 (0.61)	4.15 (0.73)	4.79 (0.47)	0.64 (0.55)
Second subscale: AP teachers' perceptions of students' preparedness for success in AP courses (Items 5-10)	5.23 (0.33)	5.18 (0.37)	-0.05 (0.19)	4.72 (0.71)	5.14 (0.48)	0.42 (0.37)
Composite: AP teachers' perceptions of student preparedness	4.91 (0.36)	4.87 (0.36)	-0.04 (0.25)	4.43 (0.66)	4.96 (0.43)	0.53 (0.39)

[a]Likert scale ranged from 1 (strongly disagree) to 6 (strongly agree)

The mean preparedness ratings increased for the treatment group across both subscales; whereas, for the control group, the mean preparedness ratings decreased for both subscales (see Table 5.16). Notably, from the pre-test to the post-test, the composite mean Likert-scale score for perceptions of preparedness decreased by 0.04 for the control group and increased by 0.53 for the treatment group. Additionally, from the pre-test to the post-test, the composite standard deviation decreased for the treatment group (from 0.66 to 0.43)—which indicated a decrease in variation in participants' perceptions of student preparedness for success in AP courses—compared to no change in the standard deviation for control group. Finally, participants in the control and treatment groups did not begin with the same perceptions of student preparedness for AP courses according to the pre-test subscores and composite score (see Table 5.16); thus, the analysis focused on examining the differences from pre to post between the control and treatment group.

The first perceptions of preparedness subscale measured AP teachers' perceptions of AP students' repertoire of effective learning and studying strategies. Repeated measures ANOVA compared teachers' perceptions of student preparedness for success in AP courses before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 10.22$, $p = .003$. An independent samples *t*-test was used to reveal particular differences. All assumptions for independent samples *t*-tests were met. The *t*-test compared the mean change in the first perceptions of student preparedness subscale for teachers in the treatment ($M = 0.64$, $SD = 0.55$) and control groups ($M = -0.03$, $SD = 0.61$); $t(33) = -3.36$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the first perceptions of student preparedness subscale than teachers in the control group.

The second perceptions of preparedness subscale measured AP teachers' perceptions of AP students' preparedness for success in AP courses. Repeated measures ANOVA compared teachers' perceptions of student preparedness for success in AP courses before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 17.9$, $p < .001$. An independent samples *t*-test was used to reveal particular differences. All assumptions for independent samples *t*-tests were met. The *t*-test compared the mean change in the second perceptions of student preparedness subscale for teachers in the treatment ($M = 0.42$, $SD = 0.37$) and control groups ($M = -0.05$, $SD = 0.19$); $t(33) = -4.26$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the second perceptions of student preparedness subscale than teachers in the control group.

Repeated measures ANOVA compared the composite perceptions of student preparedness for success in AP courses scores collected before and after the intervention. ANOVA results indicated differences among the groups, $F(1,33) = 22.5$, $p < .001$. An independent samples *t*-test was used to reveal particular differences. All assumptions for independent samples *t*-tests were met. The *t*-test compared the mean change in the composite perceptions of student preparedness scale for teachers in the treatment ($M = 0.53$, $SD = 0.39$) and control groups ($M = -0.04$, $SD = 0.25$); $t(33) = -4.74$, $p < .001$. This result indicated that teachers in the treatment group demonstrated more gains in the composite perceptions of student preparedness scale than teachers in the control group.

The gains in teachers' perceptions of preparedness across the two subscales and the composite scale for the treatment group compared to the control group suggest the AP PLC positively influenced teachers' perceptions of students' preparedness for success in AP courses, perhaps by teachers infusing retrieval opportunities during instruction and by enhancing students' study strategies (see Table 5.17).

Table 5.17

Mean Change in Teachers' Perceptions of Student Preparedness for AP Courses

Scale (number of items)	Control mean difference (SD)	Treatment mean difference (SD)	*t*-test
First subscale (4)	-0.03 (0.61)	0.64 (0.55)	$t(33) = -3.36$, $p < .001$
Second subscale (6)	-0.05 (0.19)	0.42 (0.37)	$t(33) = -4.26$, $p < .001$
Composite scale (10)	-0.04 (0.25)	0.53 (0.39)	$t(33) = -4.74$, $p < .001$

The analysis of qualitative data from interviews with participants in the treatment group helped reveal rich, descriptive details about how and why the AP PLC supported these increased perceptions of preparedness among teachers. Thematic analysis (Braun & Clarke, 2006) of interviews ($n = 5$) with participants following the AP PLC identified how teachers perceived the

AP PLC may indirectly enhance their students' preparedness for AP coursework. The codebook for the interview data is presented in Appendix Q. Table 5.18 summarizes the three themes that emerged regarding how the AP PLC influenced teacher perception of student preparedness: *specific strategies*, *student growth,* and *challenges of virtual learning*.

Table 5.18

Themes for how the AP PLC Influenced Teachers' Perceptions of Their Students' Preparedness for AP Courses

Theme	Definition
Specific strategies	A range of skills and methods teachers and students can use to enhance durable and flexible learning
Student growth	Evidence observed by AP teachers indicating academic progress their students made that they attributed to retrieval strategies
Challenges of virtual learning	Practical barriers due to the virtual learning mode of instruction that may have mitigated some of the benefits of retrieval strategies

Participants reported how the AP PLC helped them provide their students with *specific strategies* to use when learning and studying, which may explain the increase in participants' perceptions of students' repertoire of strategies that were observed in the quantitative data. Participant I3 explained how they overestimated their AP students' skill set for effective learning and studying:

> I kind of assumed that they had the skills of at the beginning of the year and then as we progress through I realized, they didn't. One of the biggest ones, but simple is vocab, like we would talk about vocab in class and say okay and make sure you write this down. And then I was finding later that I don't think they really were doing that, so I put together some vocab lists for them later on. I'd give them the terms, they'd go through and define the terms later on. And I really encouraged them to use either flashcards or Quizlet.

Participant I5 also described how they found that using simple flashcards benefited their students' learning:

> A new strategy that I found from the PLC is making index cards. I've honestly not used index cards in my class before and I'm like not ashamed I mean, you know, just learning

> to do it but, when I use the index cards rather than having them just copy the information, they have tools they can use for retrieval.

Participant I4 explained how they were surprised that AP students eagerly engaged in low-stakes self-quizzes, even when they were not graded:

> They prefer like the low stakes type of assignments, quizzes. So, I've been incorporating those as warm ups. And they're doing better. And I said what do you think is the difference here, and they're like well it's not graded. And I was thinking the opposite. I was thinking okay, if I tell them it's not for a grade they're just gonna blow it off, but they didn't. Plus, when it's not graded, they're less likely to look at their notes and more likely to try to pull it out of their brain.

Further, participants described strategies specific to their content areas that they added to students' repertoire of effective learning and studying strategies. For example, Participant I5 explained examples of creativity and arts integration:

> Some of them would draw smiley faces using the diagram. And we'll use the eyes for the two and the four chord and the mouth for the dominant chord. And these creative illustrations would help to embed that in lasting thing memory that we're looking to get them to have through you know durable learning. Students started to realize they can create their own creative ways to help them remember.

Collectively, participants explained how the AP PLC provided them with various *specific strategies* that they could pass along to their students, perhaps leading to increased teachers' perceptions of their students' repertoire of effective learning and studying strategies.

Participants reported how the AP PLC provided them with support to better prepare their students for academic success, which may explain the increase in participants' perceptions of student preparedness for AP courses observed in the quantitative data. Participants described various examples of *student growth* they observed throughout the duration of the AP PLC. Generally, Participant I2 explained, "I can certainly see changes in scores in regards to some students, so it's been a positive." Participant I1 also described how they generally observed student growth that resulted from strategies implemented from the AP PLC:

> One of the changes I made from this AP PLC was using some of these strategies. So, I would say it definitely promoted like student growth, and I saw some students understanding content better, and like kind of how to study and how they're pulling that information out.

Participants described that some students, who initially demonstrated resistance to using the strategies, eventually understood the value and benefits of using the strategies. Participant I4 explained:

> I think that with retrieval that maybe they're resistant, or have some kind of like resistance to thinking about it in the beginning. Maybe because it's harder. But I think that that was far more effective in the long run and was super helpful for the students who were doing everything with integrity. And they noticed that and told me that.

Participants explained various ways they have noticed student growth in their specific content areas. For example, Participant I5 explained:

> I try to get them to work through it a little bit longer and I use more direct questioning and leading questions, rather than just giving them the answer right away, and what I'm finding is over the long term, that it is helping them become more independent, as literate musicians, and as readers of music, and that's kind of what I found over the course of this semester.

Participant I5 further explained their students demonstrated increased self-confidence as a major area of student growth, and they attributed that to the strategies conferred from the AP PLC:

> I think they are much better prepared because of the self confidence that the methods, the PLC provided for them. They now have an understanding that when they are given an aural prompt, they don't have to sit there and wait and panic for the next listen, but rather they can use their own thinking skills to retrieve that information. And because they have that confidence, they're going to be able to go into the AP exam and feel more confident, hopefully produce better results. And as free-thinking musicians in the future and outside of the AP class.

Collectively, participants explained how the AP PLC increased their perceptions of their students' preparedness for academic success in AP courses because teachers observed *student growth* when they enacted the retrieval strategies.

An unanticipated but relevant theme emerged in response to a mode of instruction new to teachers and students (i.e., virtual instruction). Specifically, participants reported how the *challenges of virtual learning* may have mitigated some of their potential to effectively implement the strategies and to observe the effects of the strategies on their AP students. Thus, the challenges of virtual learning may have mitigated some of the increases in perceptions of student preparedness for AP courses observed in the quantitative data. Participants explained the ability to observe student behavior during virtual learning is challenging or even impossible if students do not have cameras turned on. Thus, participants expressed difficulty in being able to observe whether or not students were actually practicing retrieval during class. For example, Participant I2 explained: "I know, and the students know it's tough to really navigate this environment, it's tough to tell who is being genuine with actually using retrieval." Participant 4 explained how, unlike in a physical classroom, teachers cannot readily see if students are using other resources to access answers: "You know, in this virtual environment it's hard to tell if they're, you know, looking up answers instead of retrieving, it's kind of hard to tell." Participant I3 echoed that concern: "I think right now in the virtual world, one of the big drawbacks is that they can look up the answers. It's just a big thing that we haven't been able to prevent." Despite describing several areas of student growth attributed to strategies leveraged from the AP PLC, participants acknowledged the *challenges of virtual learning* may have mitigated some of the benefits of the strategies from the AP PLC for students. Specifically, the virtual mode of instruction may have limited changes in teachers' perceptions of student preparedness because teacher perceptions are based on opportunities to observe their students and student performance, which are relatively reduced in a virtual setting compared to in-person.

In summary, the quantitative analysis revealed that teachers in the treatment group reported perceiving significantly increased levels of students' preparedness for success in AP courses after the AP PLC compared to the control group. The qualitative analysis revealed that

AP teachers described how the AP PLC helped them provide their students with specific strategies to use when learning during class and when studying on their own. Additionally, AP teachers described various examples of their students' growth they observed during the AP PLC. Finally, AP teachers acknowledged that some challenges of virtual learning may have mitigated some of the potential to effectively implement the strategies and to observe the effects of the strategies on their AP students. Overall, AP teachers perceived that the AP PLC supported their students' preparedness for success in AP courses.

RQ5: What is the difference between AP students' unit test scores before and after their teachers participated in the AP PLC compared to a control group?

Participants reported three aggregate, mean class unit exam scores to examine the effect of the AP PLC on student performance. Two of these student performance scores occurred before the AP PLC; a unit exam given during December 2019 and a unit exam given during September 2020. One of these student performance scores occurred after the AP PLC; a unit exam given during December 2020. The *pre* unit exam given during December 2019 shared the same unit content as the *post* unit exam given during December 2020; however, the mode of instruction differed between those two exams (i.e., the December 2019 exam was during in-person learning; whereas, the December 2020 exam was during virtual learning). The *pre* unit exam given during September 2020 shared the same mode of instruction as the *post* unit exam given during December 2020 (i.e., virtual learning); however, the unit content differed between these two exams as the two exams occurs during different times in the curricula. Table 5.19 shows these three aggregate mean unit exam scores reported by participants in the control (n = 13) and treatment (n = 22) groups.

Table 5.19

AP Students' Aggregate Mean Unit Exam Scores Completed Before and After the AP PLC

Unit exam	Mean percent score (SD)	
	Control group (*n* = 13)	Treatment group (*n* = 22)
December 2019 **Pre**-AP PLC	81.4 (4.17)	79.6 (4.91)
September 2020 **Pre**-AP PLC	82.6 (3.61)	80.3 (4.74)
December 2020 **Post**-AP PLC	81.7 (3.51)	82.1 (6.78)

Changes in pre-AP PLC and post-AP PLC aggregate mean unit exam scores were observed in the control and treatment groups (see Table 5.19). The changes in mean unit exam scores were greater for students in the treatment group compared to the control group. The difference in mean pre-AP PLC and post-AP PLC unit exam scores were compared for the treatment and control groups when the same content and same mode of instruction were tested (Table 5.20).

Table 5.20

Difference Between AP Students' Mean Unit Exam Scores Completed Before and After the AP PLC

Difference between pre-AP PLC and post-AP PLC unit exams	Group	Mean difference	Standard deviation
December 2019 to December 2020 (same content)	Control	0.32	4.11
	Treatment	2.51	7.25
September 2019 to December 2020 (same mode of instruction)	Control	-0.85	2.78
	Treatment	1.82	6.69

Two independent samples *t*-tests compared the changes in mean exam scores observed for the treatment and control groups over two time intervals. All assumptions for independent samples *t*-tests were met. The first *t*-test compared the change in treatment group mean exam scores from December 2019 to December 2020 and the change in control group mean exam scores from December 2019 to December 2020. This analysis evaluated differences in the scores of the same content but different modes of instruction (i.e., in-person and virtual). This *t*-test compared the mean change in exam scores for the treatment group ($M = 2.51$, $SD = 7.25$) and the control group ($M = 0.32$, $SD = 4.11$); $t(33) = 0.995$, $p = .163$. The second *t*-test compared the change in treatment group mean exam scores from September 2020 to December 2020 and the change in control group mean exam scores from September 2020 to December 2020. This analysis evaluated differences in the scores of the same mode of instruction (i.e., virtual) but different content. This *t*-test compared the mean change in exam scores for the treatment group ($M = 1.82$, $SD = 6.69$) and the control group ($M = -0.85$, $SD = 2.78$); $t(33) = 1.36$, $p = .091$.

In summary, modest changes in AP students' aggregate mean unit exam scores were observed for AP teachers in the treatment group when the same content was tested ($M = 2.51$) and when the same mode of instruction was tested ($M = 1.82$). However, comparisons of the observed changes between the treatment and control groups indicated no significant differences between the groups. Possible interfering conditions are discussed in the limitations section below.

Conclusions

The first research question sought to understand how teachers described their experience with the AP PLC. Quantitative analysis of survey data ranked on a one to six Likert-scale revealed teachers found the AP PLC meaningful ($\bar{x} = 5.76$, $SD = 0.30$) and engaging ($\bar{x} = 5.73$, $SD = 0.42$) at the conclusion of the intervention. Qualitative analysis of open-ended survey questions and document analysis of lesson elements provided descriptions of how teachers found the AP PLC meaningful and engaging. Generally, the most meaningful and engaging components of the new learning and collaborative portions of the AP PLC were the presenter's modeling of effective retrieval strategies, the evidence from research that informed the strategies, and the sharing of ideas among colleagues. Overall, these findings suggest that teachers were able to apply what they learned in the AP PLC meaningfully to their AP courses and that teachers were actively engaged in the learning and collaborative activities during the AP PLC.

The second research question sought to understand to what extent AP teachers' knowledge and self-efficacy of retrieval practice strategies increased in response to the AP PLC compared to a control group. Quantitative analysis of Likert-scale survey data revealed the AP PLC increased teachers' knowledge of retrieval practice strategies across the three subscales. Specifically, teachers' definitional knowledge of retrieval practice strategies increased more for teachers in the treatment group than the control group ($t[33] = -4.04$, $p < .001$), teachers' knowledge of instructional practices that evoke retrieval in students increased more for teachers in the treatment group than the control group ($t[33] = -5.53$, $p < .001$), teachers' knowledge of how retrieval practice appears in classroom activities increased more for teachers in the treatment group than the control group ($t[33] = -5.37$, $p < .001$), and teachers' composite knowledge of retrieval strategies increased more for teachers in the treatment group than the control group ($t[33] = -5.16$, $p < .001$). Qualitative analysis of interviews with teachers in the treatment group provided descriptions of how and why these increases in teachers' knowledge were observed. Generally, teachers described the AP PLC as prompting them to more intentionally and conscientiously incorporate retrieval strategies in their classes and teachers described various complementary strategies they learned during the AP PLC that they infused into their instructional practices. Overall, the AP PLC enhanced AP teachers' knowledge of retrieval strategies that research has shown supports durable and flexible learning.

Quantitative analysis of Likert-scale survey data revealed the AP PLC increased teachers' self-efficacy for using retrieval practice strategies in their classes across the three subscales. Specifically, teachers' self-efficacy to employ instructional strategies that promote retrieval increased more for teachers in the treatment group than the control group ($t[33] = -3.49$, $p < .001$), teachers' self-efficacy to employ instructional strategies that optimize the benefits of retrieval with complementary strategies increased more for teachers in the treatment group than the control group ($t[33] = -3.38$, $p < .001$), teachers' self-efficacy to encourage students to use retrieval when studying on their own increased more for teachers in the treatment group than the control group ($t[33] = -3.78$, $p < .001$), and teachers' composite self-efficacy for using retrieval strategies increased more for teachers in the treatment group than the control group ($t[33] = -4.40$, $p < .001$). Qualitative analysis of interviews with teachers in the treatment group provided descriptions of how and why these increases in teachers' self-efficacy were observed. Generally, teachers described that the AP PLC helped them: (a) make subtle changes to their practice to incorporate retrieval opportunities for students, (b) utilize a range of low-tech and high-tech classroom activities that promote retrieval, and (c) teach their students how to use retrieval strategies when studying on their own. Overall, the AP PLC enhanced AP teachers' self-efficacy for using retrieval strategies that research has shown supports durable and flexible learning.

The third research question sought to understand to what extent AP teachers increased their use of retrieval practice strategies in their AP classes as a result of the AP PLC. Each week during the AP PLC teachers reported the number of times they used a retrieval strategy in their AP class during the previous week. Generally, teachers increased their use of retrieval strategies over the duration of the AP PLC. There was a strong, positive correlation between time (i.e., week number) and mean strategy use ($r = .865$, $n = 22$, $p < .001$). Overall, AP teachers significantly increased their use of retrieval practice in their AP classes as a result of the AP PLC.

The fourth research question sought to understand AP teachers' perceptions of how well students are prepared for success in AP courses after the AP PLC compared to the control group. Quantitative analysis of Likert-scale survey data revealed the AP PLC increased teachers' perceptions of their students' preparedness for AP courses across the two subscales. Specifically, teachers' perceptions of students' repertoire of effective learning and studying strategies increased more for teachers in the treatment group than the control group ($t[33] = -3.36$, $p < .001$), teachers' perceptions of students' preparedness for success in AP courses increased more for teachers in the treatment group than the control group ($t[33] = -4.26$, $p < .001$), and teachers' composite perceptions of students' preparedness for academic success increased more for teachers in the treatment group than the control group ($t[33] = -4.74$, $p < .001$). Qualitative analysis of interviews with teachers in the treatment group provided descriptions of how and why these increases in teachers' perceptions of students' preparedness were observed. Generally, teachers described: (a) the AP PLC helped them employ a range of specific strategies and methods that may support their students in becoming better learners, (b) evidence they observed of their students' academic growth that they attributed to retrieval strategies, and (c) challenges presented by the virtual learning format that may have mitigated some of the potential benefits of using and benefiting from retrieval strategies. Overall, the AP PLC enhanced AP teachers' perceptions of their students' preparedness for success in AP courses, in part due to teachers' observations of improvements that students showed when retrieval strategies were implemented.

The fifth research question sought to understand the difference between AP students' unit test scores before and after their teachers participated in the AP PLC compared to a control group. Differences in mean unit test scores were measured when the same content was tested for the treatment group ($M = 2.51$) and control group ($M = 0.32$) and when the same mode of instruction (i.e., virtual) was tested for the treatment group ($M = 1.82$) and control group ($M = -0.85$). The post-AP PLC aggregated mean unit test scores for the treatment group were compared to the pre-AP PLC aggregated mean unit test scores when the same content was tested ($t[33] = 0.995$, $p = .163$) and when the same mode of instruction (i.e., virtual) was tested ($t[33] = 1.36$, $p = .091$). The limitations and challenges to teaching and learning virtually during the pandemic may have mitigated some of the potential benefits that may have been observed on student test scores. Nonetheless, the observed increase in students' unit test scores was modestly greater for students whose teachers participated in the AP PLC than for students whose teachers did not participate in the AP PLC.

Overall, the findings of this study generally supported the theory of change (see Figure 4.1) that the AP PLC aimed to achieve. That is, the intervention increased proximal outcomes (i.e., teachers' knowledge of retrieval strategies and teachers' self-efficacy for using retrieval strategies), which in turn, may have increased the slightly more distal outcome of teachers' frequency of using retrieval strategies. Further, those three outcomes may have positively influenced the slightly more distal outcome of teachers' perceptions of student preparedness for AP courses. In turn, those four outcomes may have positively influenced the slightly more distal outcome of students' performance in AP courses, as measured by unit exam test scores. Collectively, this study observed increases across these outcomes that are represented in the theory of change for the AP PLC.

Limitations

Several factors may have limited the potential to observe more compelling findings in this study. First, the AP PLC was initially conceived as an in-person professional learning experience, but due to the pandemic, the AP PLC was conducted virtually. Collaboration among teachers in a PLC may be less effective virtually than in-person, which may have mitigated some of the potential effects on the outcomes measured. However, considering emerging technologies and everything that has been recently learned about the potential of working and learning virtually, virtual professional learning may become increasing important and common, and this study may be used to inform future, virtual professional learning opportunities. Second, the virtual mode of instruction used for students may have limited teachers' opportunities to infuse retrieval learning and studying strategies into their practice. For example, average weekly instructional time in the treatment and control schools was reduced from approximately 350 minutes per week during recent previous school years to approximately 200 minutes per week during time when the AP PLC was conducted. This decreased instructional time may have inhibited teachers' opportunities to infuse retrieval strategies learned during the AP PLC. Similarly, teachers who were experienced in teaching in-person had to learn effective methods and strategies for teaching virtually during the time when the AP PLC was conducted, possibly further inhibiting these teachers' opportunities to infuse retrieval strategies in their classes. Third, teachers' perceptions of their students' performance, capacity, and fidelity of actually practicing retrieval when the strategies were implemented may have been limited by the virtual mode of instruction that reduced teachers' ability to observe how students were working, because students in the treatment school typically did not turn on their cameras during virtual instruction. Fourth, the sample size ($N = 35$), although sufficient, was not large and may have limited the potential to observe more compelling findings. Fifth, the inability to obtain more distal outcome measures, particularly students' AP exam scores, may have limited the potential to observe additional compelling findings. Finally, the comparisons in student performance (i.e., unit exam scores) on the same content was limited by having a varying mode of instruction (i.e., virtual and in-person) and the comparisons in student performance with the same mode of instruction has limited by students being tested on different content. Overall, several factors may have limited the potential to observe more compelling findings in this study.

Several factors may have limited the generalizability of this study. First, the AP PLC was conducted virtually, and the participants implemented the strategies learned through the AP PLC with their students using virtual instruction. Therefore, the generalizability of the AP PLC to in-person professional learning and the generalizability of implementing the strategies with in-person classes cannot be assumed. Second, all participants in this student were AP teachers. Therefore, the generalizability of a PLC that features retrieval learning and studying strategies to non-AP contexts cannot be assumed. However, previous research suggested retrieval strategies may positively influence a range of academic contexts (Agarwal, 2017; Bobby & Meiyappan, 2018; Horvath et al., 2017; McDaniel et al., 2013). Finally, the demographic characteristics of treatment school may not align with some other schools and thereby limited the possible generalizations that can be made. For example, 95% of the participating teachers from the treatment school were White, 84% of the students in the treatment school were White, and 13% of students in the treatment school qualified for free or reduced meals in 2019. The control school was selected because it was the best matched school in the same district to the treatment school based on available academic metrics and demographics (i.e., 100% of the participating teachers from the control school were White and 6% of the students in the control school qualified for free or reduced meals in 2019); however, the student body in the control school was more racially diverse (e.g., 53% White) than the treatment school. Overall, several factors may have limited the generalizability of this study.

Implications for Practice

Despite abundant research that demonstrated the benefits for students of using retrieval strategies on building durable and flexible learning (Agarwal et al., 2012; Butler, 2010; Dunlosky et al., 2013; Karpicke & Blunt, 2011; Roediger & Butler, 2011), the knowledge and application of these strategies are often underutilized in teachers' instructional practices (Karpicke, 2016; Roediger & Pyc, 2012). Roediger and Pyc (2012) suggested that incorporating instructional practices that promote retrieval in students may be a practical and inexpensive way to enhance student learning. However, other researchers, such as Daniel (2012), have recommended steps that be taken before translating science of learning research to educational practice. These yet unrealized steps may be associated with the underutilization of retrieval strategies in teachers' instructional practices. This evaluation of the AP PLC served to address some of Daniel's (2012) suggestions of steps required before translating science of learning research to practice; specifically, "careful experimentation in select classroom contexts" (p. 251) and "development and design of classroom/teacher-friendly methods…into everyday practice" (p. 251). Thus, the implementation and evaluation of the AP PLC has taken important steps to help bridge the gap between research and instructional practice.

Notably, the AP PLC was an inexpensive and relatively short-term (i.e., 7.5 hours over 13 weeks) professional learning experience that positively influenced various teacher and student outcomes. The AP PLC may serve as a model of a way to produce positive outcomes for teachers and students for educational contexts that have limited financial resources and limited time for professional learning. The positive outcomes observed in the evaluation of the AP PLC may be achievable because they require only modest changes to teachers' instructional behaviors, yet modest changes to instruction may translate into substantial growth in student learning. Such modest changes in teachers' instructional behaviors may be readily transferable to all future classes taught. Additionally, this study showed how a local, contextualized, user-focused, grassroots professional learning experience can lead to measurable positive outcomes and may inspire other experienced teachers to conduct design or action research. Further, teachers who participated in the AP PLC may have enhanced their students' understanding and use of effective learning and studying strategies, which may build academic skills and behaviors in those students that are not necessarily limited to a particular AP course; rather, when students learn optimal learning and studying strategies, those are skills and behaviors that students may apply to all their future academic endeavors.

Future Research

Several recommendations for future research may extend the findings of this study. First, conducting a similar AP PLC in-person may inform the field to what extent the findings of this study may be observed in an in-person professional learning and instructional context. Second, measuring more distal student outcomes (e.g., AP exam scores, overall course grades, future course grades) may support understanding how durable the academic influences of the AP PLC are for students. Third, measuring student perceptions of learning and studying with the strategies may support understanding how students interact with the strategies, which may in turn, inform iterative improvements to the AP PLC and the influence of the strategies on student learning. Fourth, measuring teacher outcomes (e.g., knowledge of the strategies, self-efficacy for using the strategies, frequency of using the strategies, and perceptions of student preparedness) over a longer time period may support understanding how durable the changes in instructional practices that were observed in this study are for teachers. Finally, scaling up the AP PLC to various audiences may support understanding if this line of professional learning is generalizable to other contexts. Specifically, the strategies learned and implemented through the AP PLC may be substantially important to non-AP students and teachers, as well, because retrieval strategies have been shown to have benefits for students in various academic contexts (Agarwal, 2017; Bobby & Meiyappan, 2018; Horvath et al., 2017; McDaniel et al., 2013). Additionally, scaling up the AP PLC virtually may be feasible because of: (a) the logistical ease by which geographically distant teachers may participate, (b) the low financial cost required to implement the AP PLC, and (c) the short time frame during which the AP PLC can be completed. Further, conducting the AP PLC in contexts with various demographics may support understanding to what extent the influences of the AP PLC found in this study may also be found in other contexts. Overall, there are several recommendations for future research that may be valuable to extend the findings of this study.

References

Ackerman, P. L., Kanfer, R., & Calderwood, C. (2013). High school Advanced Placement and student performance in college: STEM majors, non-STEM majors, and gender differences. *Teachers College Record, 115*(10), 1-43. Retrieved from https://www.tcrecord.org/content.asp?contentid=17149

Agarwal, P.K., Bain, P.M., & Chamberlain, R.W. (2012). The value of applied research: Retrieval practice improves classroom learning and recommendations from a teacher, a principal, and a scientist. *Educational Psychology Review, 24*, 437-448. doi:10.1007/s10648-012-9210-2

Agarwal, P.K., D'Antonio, L., Roediger, H.L., III, McDermott, K.B., & McDaniel, M.A. (2014). Classroom-based programs of retrieval practice reduce middle school and high school students' test anxiety. *Journal of Applied Research in Memory and Cognition, 3*, 131-139. doi:10.1016/j.jarmac.2014.07.002

Agarwal, P.K., Finley, J.R., Rose, N.S., & Roediger, H.L. (2017). Benefits from retrieval practice are greater for students with lower working memory capacity. *Memory, 25*, 764-771. doi:10.1080/09658211.2016.1220579

Agarwal, P. K., & Roediger, H. L., III. (2018). Lessons for learning: How cognitive psychology informs classroom practice. *Kappan*. 8-12. doi:10.1177/0031721718815666

American Community Survey. (n.d.). United States Census Bureau. Retrieved from https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2015/

Anderson, E. R. (2017). Accommodating change: Relating fidelity of implementation to program fit in educational reforms. *American Educational Research Journal, 54*, 1288–1315. doi:10.3102/0002831217718164

Arce-Trigatti, P. (2018). The impact of state-mandated Advanced Placement programs on student outcomes. *Economics of Education Review, 63*, 180-193. doi:10.1016/j.econedurev.2018.02.001

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. *Teaching and Teacher Education, 27*, 10–20. doi:10.1016/j.tate.2010.08.007

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191-215. doi:10.1037/0033-295X.84.2.191

Barbour, M., & Malcahy, D. (2006). An inquiry into retention and achievement differences in campus based and web based AP courses. *The Rural Educator, 27*, 8-12. doi:10.35608/ruraled.v27i3.489

Barbour, M., & Mulcahy, D. (2008). How are they doing?: Examining student achievement in virtual schooling. *Education in Rural Australia, 18*, 63-74. Retrieved from https://www.spera.asn.au/education-rural-australia-vol-27-no-3-2006/

Barnard-Brak, L., McGaha-Garnet, V., & Burley, H. (2011). Advanced Placement course enrollment and school-level characteristics. *NASSP Bulletin, 95*, 165-174. doi:10.1177/0192636511418640

Barton, K., & Smith, L. (2000). Themes or motifs? Aiming for coherence through interdisciplinary outlines. *The Reading Teacher, 54*, 54-63. Retrieved from http://auburn.edu/~silvesb/smicha/Barton&Smith.pdf

Beane, J. (1997). *Curriculum Integration*. New York, NY: Teachers College Press.

Bjork, E. L., & Bjork, R. A. (2014). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In M. A. Gernsbacher and J. Pomerantz (Eds.), *Psychology and the real world: Essays illustrating fundamental contributions to society (2nd edition).* (pp. 59-68). New York, NY: Worth.

Bjork, R., Dunlosky, J., & Kornell, N. (2012). Self-regulated learning: Beliefs, techniques, and illusions. *Annual Review of Psychology, 64*, 417-444. doi:10.1146/annurev-psych-113011-143823

Bobby, Z., & Meiyappan, K. (2018). "Test-enhanced" focused self-directed learning after the teaching modules in biochemistry. *Biochemistry and Molecular Biology Education, 46*, 472-477. doi:10.1002/bmb.21171

Braun, V., & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3,* 77–101. doi:10.1191/1478088706qp063oa

Bronfenbrenner, U. (1994). Ecology models of human development. In T. N. Postlewaite & Husen, T. (Eds.), *International encyclopedia of education* (2nd ed., Vol. 3, pp. 1643-1647). Oxford, England: Elsevier.

Bronfenbrenner, U., & Morris, P. A. (2006). The biological model of human development. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology*: *Theoretical models of human development* (6th ed., Vol. 1, pp. 793-828). Hoboken, NJ: John Wiley & Sons. doi:10.1002/9780470147658.chpsy0114

Brown, P. C., Roediger, H. L., III, & McDaniel, M. A. (2014). *Make it stick: The science of successful learning*. Cambridge, MA: Harvard University Press.

Bryan, R. R., Glynn, S. M., & Kittleson, J. M. (2011). Motivation, achievement, and advanced placement intent of high school students learning science. *Science Education, 95*, 1049–1065. doi:10.1002/sce.20462

Bryk, A., Gomez, L., Grunow, A., & LeMahieu, P. G. (2015). *Learning to improve: How America's schools can get better at getting better*. Cambridge, MA: Harvard Education Press.

Burney, V. (2010). High achievement on Advanced Placement Exams: The relationship of school-level contextual factors to performance. *Gifted Child Quarterly, 54*, 116-126. doi:10.1177/0016986209355972

Busso, D. S., & Pollack, C. (2015). No brain left behind: Consequences for neuroscience discourse for education. *Learning, Media, and Technology, 40*, 168-186. doi:10.1080/17439884.2014.908908

Butler, A. C. (2010). Repeated testing produces superior transfer of learning relative to repeated studying. *Journal of Experimental Psychology, 36*, 1118-1133. doi:10.1037/a0019902

Calvert, L. (2016). *Moving from compliance to agency: What teachers need to make professional learning work*. Oxford, OH: Learning Forward and National Commission on Teaching & America's Future.

Campbell, D. M., Brown, R., & Perry, E. (2009). Trends in Advanced Placement science and mathematics test-taking among female students in California: A latent variable approach. *Electronic Journal of Science Education, 13*, 62-82. Retrieved from http://ejse.southwestern.edu

Christie, C. A., Inkelas, M., & Lemire, S. (2017). *Improvement Science in Evaluation: Methods and Uses*. Hoboken, NJ: Wiley & Sons.

Cisneros, J., Holloway-Libell, J., Gomez, L., Corley, K. M., & Powers, J. M. (2014). The

Advanced Placement opportunity gap in Arizona: Access, participation, and success. *AASA Journal of Scholarship and Practice, 11*, 20-33. Retrieved from http://hdl.handle.net/10536/DRO/DU:30093709

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18,* 947–967. doi:10.1016/s0742-051x(02)00053-7

Coffey, H., & Farinde-Wu, A. (2016). Navigating the journey to culturally responsive teaching: Lessons from the success and struggles of one first-year, Black female teacher of Black students in an urban school. *Teaching and Teacher Education, 60*, 34-33. doi:10.1016/j.tate.2016.07.021

College Board. (2014). 10th annual AP® report to the nation. *The College Board.* Retrieved from https://research.collegeboard.org/programs/ap/data/nation/2014

College Board. (2018). AP program participation and performance data. *The College Board.* Retrieved from https://research.collegeboard.org/programs/ap/data/participation/ap-2018

Conger, D., Long, M. C., & Iatarola, P. (2009). Explaining race, poverty, and gender disparities in advanced course-taking. *Journal of Policy Analysis and Management, 28*, 555-576. doi:10.1002/pam.20455

Corra, M., Carter, J. S., & Carter, S. K. (2011). The interactive impact of race and gender on high school advanced course enrollment. *The Journal of Negro Education, 80*, 33-46. Retrieved from http://www.journalnegroed.org/winter2011.html

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and Conducting Mixed Methods Research*. Thousand Oaks, CA: SAGE.

Creswell, J. W., & Plano-Clark, V. L. (2018). *Designing and Conducting Mixed Methods*

Research. Thousand Oaks, CA: SAGE.

Daniel, D. B. (2012). Promising principles: Translating the science of learning to educational practice. *Journal of Applied Research in Memory and Cognition, 1*, 251-253. doi:10.1016/j.jarmac.2012.10.004

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (with Espinoza, D.). (2017). *Effective teacher professional development.* Palo Alto, CA: Learning Policy Institute. Retrieved from https://learningpolicyinstitute.org/product/teacher-prof-dev

de la Varre, C., Irwin, M., Jordan, A., Hannum, W., & Farmer, T. (2014). Reasons for student dropout in an online course in rural K-12 setting. *Distance Education, 35*, 324-344. doi:10.1080/01587919.2015.955259

Desimone, L. M., & Garet, M. S. (2015). Best practices in teachers' professional development in the United States. *Psychology, Society, & Education, 7,* 252–263. doi:10.25115/psye.v7i3.515

Desimone, L. M., & Hill, K. L. (2017). Inside the black box: Examining mediators and moderators of a middle school science intervention. *Educational Evaluation and Policy Analysis, 39*, 511-536. doi:10.3102/0162373717697842

Desimone, L. M., & Le Floch, K. C. (2004). Are we asking the right questions? Using cognitive interviews to improve surveys in education research. *Educational Evaluation and Policy Analysis, 26*, 1-22. doi:10.3102/01623737026001001

De Smul, M., Heirweg, S., Van Keer, H., Devos, G., & Vandevelde, S. (2018). Teacher Self-Efficacy Scale to Implement Self-Regulated Learning [Database record]. Retrieved from PsycTESTS. doi:10.1037/t70372-000

Devonshire, I. M., & Dommett, E. J. (2010). Neuroscience: Viable applications in education? *The Neuroscientist, 16*, 349-356. doi:10.1177/1073858410370900

DuFour, R. (2007). Professional learning communities: A bandwagon, an idea worth considering, or our best hope for high levels of learning? *Middle School Journal, 39*, 4-8. doi:10.1080/00940771.2007.11461607

Duke, N., Halvorsen, A., & Strachan, S. (2016). Project-based learning not just for STEM anymore. *Phi Delta Kappan, 98*, 14-19. doi:10.1177/0031721716666047

Dunlosky, J., Rawson, K.A., Marsh, E.J., Nathan, M.J., & Willingham, D.T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*, 4-58. doi:10.1177/1529100612453266

Dusenbury, L., Brannigan, R., Falco, M., & Hansen, W. B. (2003). A review of research on fidelity of implementation: Implications for drug abuse prevention in school settings. *Health Education Research, 18*, 237–256. doi:10.1093/her/18.2.237

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York: Random House.

Evans, B. J. (2019). How college students use Advanced Placement credit. *American Educational Research Journal, 19*, 925-954. doi:10.3102/0002831218807428

Fenty, N., & Allio, A. (2017). Using distance learning to impact access of diverse learners to Advanced Placement programs. *The Quarterly Review of Distance Education, 18*, 39-56. Retrieved from https://www.infoagepub.com/qrde-issue.html?i=p59e2068bb2202

Firth, J., Smith, M., Harvard, B., & Boxer, A. (2018). Assessment as learning: The role of retrieval practice in the classroom. *Profession, 18*, 31-34. Retrieved from https://profession.mla.org/

Fischer, C., Eisenkraft, A., Fishman, B., Hubner, N., & Lawrenz, F. (2018a). Adapting to the large-scale AP Chemistry reform: An examination of teachers' challenges and instructional practices. *Journal of Chemical Education, 95*, 1701-1710. doi:10.1021/acs.jchemed.8b00151

Fischer, C., Fishman, B., Dede, C., Eisenkraft, A., Frumin, K., Foster, B., … McCoy, A. (2018b). Investigating relationships between school context, teacher professional development, teaching practices, and student achievement in response to a nationwide science reform. *Teaching and Teacher Education, 72*, 107-121. doi:10.1016/j.tate.2018.02.011

Fisher, D., & Frey, N. (2014). Effective professional development in secondary schools. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Bauserman (Eds.), *Handbook of professional development in education: Successful models and practices, PreK–12* (pp. 205–227). New York, NY: Guilford Press.

Flores, S., & Gomez, M. (2011). Strategies for increasing Advanced Placement participation for underrepresented students: Barriers, practices, and positive outcomes. *NASSP Bulletin, 95*, 65-79. doi:10.1177/0192636511406529

Flowers, L. A. (2008). Racial differences in the impact of participating in Advanced Placement Programs on educational and labor market outcomes. *Educational Foundations, 22*, 121-132. Retrieved from https://eric.ed.gov/?id=EJ839501

Foust, R. C., Hertberg-Davis, H., & Callahan, C. M. (2009). Student perceptions of the non-academic advantages and disadvantages of participation in Advanced Placement courses and International Baccalaureate programs. *Adolescence, 44*, 289-312. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/19764268

Frumin, K., Dede, C., Fischer, C., Foster, B., Lawrenz, F., Eisenkraft, A., … McCoy, A. (2018).

Adapting to large scale changes in Advanced Placement Biology, Chemistry, and Physics: The impact of online teacher communities. *International Journal of Science Education, 40*, 397-420. doi:10.1080/09500393.2018.1424962

Gagnon, D. J., & Mattingly, M. J. (2016). Advanced Placement and rural schools: Access, success, and exploring alternatives. *Journal of Advanced Academics, 27*, 266-284. doi:10.1177/1932202X16656390

Garrett, B. (2015). *Brain and Behavior: An Introduction to Biological Psychology*. Thousand Oaks, CA: Sage Publications, Inc.

Gibson, S., & Dembo, M. H. (1984). Teacher Efficacy Scale [Database record]. Retrieved from PsycTESTS. doi: 10.1037/t03431-000

Graham, P. (2007). Improving teacher effectiveness through structured collaboration: A case study of a professional learning community. *RMLE Online, 31*(1), 1-17. doi:10.1080/19404476.2007.11462044

Greer, D. C. (2017). Motivation and attention as foundations for student learning. In J. C. Horvath, J. M. Lodge, & J. Hattie (Eds.), *From the Laboratory to the Classroom: Translating Science of Learning for Teachers* (pp. 45-60). New York, NY: Routledge.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Technology Research and Development, 29*, 75-91. Retrieved from https://link.springer.com/article/10.1007BF02766777

Guskey, T. R. (2014). Measuring the effectiveness of educators' professional development. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Basuerman (Eds.), *Handbook of professional development in education: Successful models and practices, PreK–12* (pp. 447–466). New York, NY: Guilford Press.

Guskey, T. R. (2002). Professional development and teacher change. *Teachers and Teaching,* *8,* 381–391. doi:10.1080/13540600210000512

Gwinn, C. B., & Watts-Taffe, S. (2017). The impact of a vocabulary focused PLC and research based practices on teacher and student learning. *Literacy practice and research, 42*, 5-11. Retrieved from https://www.carolyngwinn.com/additional-resources

Hallett, R. E., & Venegas, K. M. (2011). Is increased access enough? Increased access to Advanced Placement courses, quality, and success in low-income urban schools. *Journal for the Education of the Gifted, 34*, 468–487. doi:10.1177/016235321103400305

Hartwig, M. K., & Dunlosky, J. (2012). Study strategies of college students: Are self-testing and scheduling related to achievement? *Psychonomic Bulletin & Review, 19*, 126-134. doi:10.3758/s13423-011-0181-y

Hattie, J. (2012). *Visible learning for teachers: Maximizing impact on learning*. New York, NY: Routledge.

Holland D., Skinner, D., Lachicotte, W., Jr., & Cain, C. (1998). Identity and agency in cultural worlds. Cambridge, MA: Harvard University Press.

Hord, S. M. (1997). *Professional learning communities: Communities of continuous inquiry and improvement.* Austin, TX: Southwest Educational Development Laboratory.

Horvath, J. C., & Lodge, J. M. (2017). A framework for organizing and translating science of learning research. In J. C. Horvath, J. M. Lodge, & J. Hattie (Eds.), *From the Laboratory to the Classroom: Translating Science of Learning for Teachers* (pp. 7-20). New York, NY: Routledge.

Horvath, J. C., Lodge, J. M., & Hattie, J. (2017). *From the Laboratory to the Classroom: Translating Science of Learning for Teachers*. New York, NY: Routledge.

Howard, T., & Terry, C., Sr. (2011). Culturally responsive pedagogy for African American students: Promising programs and practices for enhanced academic performance. *Teaching Education, 22*, 345-362. doi:10.1080/10476210.2011.608424

Iatarola, P. (2016). Implications for scaling up advanced course offerings: evidence from Florida. *Teachers College Record, 118*, 1-22. Retrieved from http://www.tcrecord.org.proxy1.library.jhu.edu/library/content.asp?contentid=20556

Iatarola, P., Conger, D., & Long, M. C. (2011). Determinants of high schools' advanced course offerings. *Educational Evaluation and Policy Analysis, 33*, 340-359. doi:10.3102/0162373711398124

Irvin, M. J., Hannum, W. H., Farmer, T. W., de la Varre, C., & Keane, J. (2009). Supporting online learning for Advanced Placement students in small rural schools: Conceptual foundations and intervention components of the facilitator preparation program. *Rural Educator*, *31*, 29-37. doi:10.35608/ruraled.v31i1.440

Jacobs, H. (1989). *Interdisciplinary curriculum: Design and implementation*. ASCD, Alexandria, VA: Edwards Brothers.

Jacobs, J., & Yendol-Hoppey, D. (2014). Effective professional development in secondary schools. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Bauserman (Eds.), *Handbook of professional development in education: Successful models and practices, PreK–12* (pp. 304-318). New York, NY: Guilford Press.

Jensen, B., Sonnemann, J., Roberts-Hull, K., & Hunter, A. (2016). *Beyond PD: Teacher professional learning in high-performing systems*. Washington, DC: National Center on Education and the Economy. Retrieved from http://www.ncee.org/wp-content/uploads/2015/08/BeyondPDWeb.pdf

Jeong, D. W. (2009). Student participation and performance on Advanced Placement exams: Do state-sponsored incentives make a difference? *Educational Evaluation and Policy Analysis, 31*, 346–366. doi:10.3102/0162373709342466

JohnBull, R. M., Hardiman, M., & Rinne, L. (2013). *Professional development effects on teacher efficacy: Exploring how knowledge of neuro- and cognitive sciences changes beliefs and practices*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Johnson. R. B. & Onwuegbuzie. A.J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(6), 14-26. https://doi.org/10.3102/0013189X033007014

Johnson, R. B. Onwuegbuzie, A.J., & Tuner, L, A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research, 1*, 112-133.

Johnston, S., & Barbour, M. (2013). Measuring success: Examining achievement and perceptions of online Advanced Placement students. *The American Journal of Distance Education, 27*, 16-28. doi:10.1080/08923647.2013.755072

Judson, E. (2017a). How science and math teachers address different course levels: Advanced Placement (AP), honors, and regular. *High School Journal, 100*, 226-249. doi:10.1353/hsj.2017.0010

Judson, E. (2017b). Science and mathematics Advanced Placement exams: Growth and achievement over time. *The Journal of Educational Research, 110*, 209-217. doi:10.1080/00220671.2015.1075188

Judson, E., & Hobson, A. (2015). Growth and achievement trends of Advanced Placement Exams in American high schools. *American Secondary Education, 43*, 59-76. doi:10.1080/00220671.2015.1075188

Kang, S. H. (2017). The benefits of interleaved practice for learning. In J. C. Horvath, J. M. Lodge, & J. Hattie (Eds.), *From the Laboratory to the Classroom: Translating Science of Learning for Teachers* (pp. 79-93). New York, NY: Routledge.

Karpicke, J. D. (2016). A powerful way to improve learning and memory. *Psychological Science Agenda*. Retrieved from: http://www.apa.org/science/about/psa/2016/06/learning-memory

Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331*, 772-775. doi:10.1126/science.1199327

Karpicke, J. D., Butler, A. C., & Roediger, H. L., III. (2009). Metacognitive strategies in student learning: Do students practice retrieval when they study on their own? *Memory, 17*, 471–479. doi:10.1080/09658320802647009

Klopfenstein, K. (2004). The Advanced Placement expansion of the 1990s: how did traditionally underserved students fare? *Education Policy Analysis Archives, 12*(6), 1-13. doi:10.14507.epaa.v12n68.2004

Klopfenstein, K., & Thomas, M. (2009). The link between Advanced Placement experience and early college success. *Southern Economic Journal, 75*, 873-891. Retrieved from https://www.jstor.org/stable/27751419

Klugman, J. (2013). The Advanced Placement arms race and the reproduction of educational inequality. *Teachers College Record, 115*(050305), 1-34. Retrieved from https://www.tcrecord.org/Issue.asp?volyear=2013&number=5&volume=115

Kolluri, S. (2018). Advanced Placement: The dual challenge of equal access and effectiveness. *Review of Education Research, 88*, 671-711. doi:10.3102/0034654318787268

Kornell, N., & Bjork, R. A. (2007). The promise and perils of self-regulated study. *Psychonomic*

Bulletin & Review, 14, 219–224. doi:10.3758/BF03194055

Laitusis, V., & Barry, C. (2012). Pre-AP® Science Vertical Teams Summer Institute evaluation summary: a one-year follow-up. *CollegeBoard*. Retrieved from https://files.eric.ed.gov/fulltext/ED561040.pdf

Learning Forward. (2011). *Standards for professional learning*. Oxford, OH: Author.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice and performance. *Journal of Vocational Behavior, 45*, 79-122. doi:10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology, 47*, 36-49. doi:10.1037/0022-0167.47.1.36

Levine, T. H. (2019). Overcome 5 PLC challenges. *The Learning Professional, 40*, 64-65. Retrieved from http://www.learingforward.com

Leviton, L. C., & Lipsey, M. W. (2007). A big chapter about small theories: Theory as method: Small theories of treatments. *New Directions for Evaluation, 2007*(114), 27–62. doi:10.1002/ev.224

Lewis, C. (2015). What is improvement science? Do we need it in education? *Educational Researcher. 44*, 54-61. doi:10.3102/0013189X15570388

Lichten, W. (2010). Whiter Advanced Placement – now? In P. Sadler, G. Sonnert, R. Tai, & K. Klopfenstein (Eds.), *AP: A critical examination of the Advanced Placement program* (pp. 233-243). Cambridge, MA: Harvard Education Press.

Lochmiller, C. N., & Lester, J. N. (2017). *An introduction to educational research: Connecting methods to practice*. Los Angeles, CA: SAGE.

Lomos, C., Hofman, R. H., & Bosker, R. J. (2011). Professional communities and student achievement: A meta-analysis. *School Effectiveness and School Improvement, 22*, 121-148. doi:10.1080/09243453.2010.550467

Lucas, S. R. (2001). Effectively maintained inequality: Education transitions, track mobility, and social background effects. *American Journal of Sociology*, *106*(6), 1642-1690. Retrieved from https://www.journals.uchicago.edu/doi/abs/10.1086/321300

Malkus, N. (2016a). AP at scale: public school students in Advanced Placement, 1990-2013. *AEI Paper & Studies, 12*(1), 1-21. Retrieved from http://www.aei.org/publication/ap-at-scale-public-school-students-in-advanced-placement-1990-2013

Malkus, N. (2016b). The AP peak: public schools offering Advanced Placement, 2000-2012. *AEI Paper & Studies, 12*(1), 1-19. Retrieved from http://www.aei.org/publication/the-ap-peak-public-schools-offering-advanced-placement-2000-12/

McBride-Davis, C. A., Slate, J. R., Moore, G. W., & Barnes, W. (2015). Advanced Placement exams, incentive programs, and cost effectiveness: a lack of equity and excellence for Black students in Texas, New York, and Florida. *The Journal of Negro Education, 84*(2), 139-153. doi:10.7709/jnegroeducation.84.2.0139

McDaniel, M.A., Thomas, R.C., Agarwal, P.K., McDermott, K.B., & Roediger, H.L., III. (2013). Quizzing in middle-school science: Successful transfer performance on classroom exams. *Applied Cognitive Psychology, 27*, 360-372. doi:10.1002/acp.2914

McKillip, M., & Rawls, A. (2013). A closer examination of the academic benefits of AP. *The Journal of Educational Research, 106*, 305-318. doi:10.1080/00220671.2012.692732

McLaughlin, J., & Jordan, G. (2010). Using logic models. In J. Wholey, H. Hatry, & K.

Newcomer (Eds.), *Handbook of practical program evaluation* (pp. 55-80). San Francisco, CA: Jossey-Bass.

Mertens, D. M. (2018). *Mixed Methods Designs in Evaluation*. Thousand Oaks, CA: Sage.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook*. Thousand Oaks, CA: SAGE.

Milewski, G. B., & Gillie, J. M. (2002). What are the characteristics of AP teachers? An examination of survey research. *The College Board*. Retrieved from https://files.eric.ed.gov/fulltext/ED561050.pdf

Moller, S., Stearns, E., Southworth, S., & Potochnick, S. (2013). Changing course: The gender gap in college selectivity and opportunities to learn in the high school curriculum. *Gender and Education, 25*, 851-871. doi:10.1080/09540253.2013.853028

Moore, G. W., & Slate, J. R. (2008). Who's taking the Advanced Placement courses and how are they doing: A statewide two-year study. *The High School Journal, 92*, 56-67. doi:10.1353/hsj.0.0013

Morano, S. (2019). Retrieval practice for retention and transfer. *Teaching Exceptional Children, 51*, 436-444. doi:10.1177/0040059919847210

Morgan, R., & Klaric, J. (2007). AP students in college: An analysis of five-year academic careers. *College Board Research Report, No. 2007-4.* Retrieved from https://files.eric.ed.gov/fulltext/ED561034.pdf

Morgan, T. L., Zakhem, D., & Cooper, W. L. (2018). From high school access to postsecondary success: an exploratory study of the impact of high-rigor coursework. *Education Science, 8*(191), 1-20. doi:10.3390/educsci8040191.

National Research Council. (2002). *Learning and understanding: Improving advanced study of* *mathematics and science in U.S. high schools*. Center for Education, Division of Behavioral and Social Sciences and Education. Washington, D.C.: National Academy Press.

Ndura, E., Robinson, M., & Ochs, G. (2003). Minority students in high school Advanced Placement courses: Opportunity and equity denied. *American Secondary Education, 32*, 21-38. Retrieved from http://www.jstor.org/stable/41064502

Neal, J. W., & Neal, Z. P. (2013). Nested or networked? Future directions for ecological systems theory. *Social Development, 22*, 722-737. doi:10.1111/sode.12018

Pan, S. C., Gopal, A., & Rickard, T. C. (2015). Testing with feedback yields potent, but piecewise, learning of history and biology facts. *Journal of Educational Psychology, 108*, 563-575. doi.org/10.1037/edu0000074

Parker, W. (2018). Projects as the spine of the course: Design for deeper learning. *Social Education, 82*, 45-48. Retrieved from https://www.socialstudies.org/system/files/publications/articles/se_820145.pdf

Parker, W. C., & Lo, J. (2016). Reinventing the high school government course: Rigor, simulations, and learning from text. *Democracy & Education, 24*(1), 1-10. Retrieved from https://democracyeducationjournal.org/home/vol24/iss1/6/

Parker, W. C., Lo, J., Yeo, A. J., Valencia, S. W., Nguyen, D., Abbott, R. D., ... Vye, N. J. (2013). Beyond breadth-speed-test: toward deeper knowing and engagement in an Advanced Placement course. *American Educational Research Journal, 50*, 1424-1459. doi:10.3102/0002831213504237

Pintrich, P.R., Smith, D.A.F., García, T., & McKeachie, W.J. (1991). *A manual for the use of the* *motivated strategies questionnaire (MSLQ)*. Ann Arbor, MI: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.

Posner, M. I., Rothbart, M. K., & Rueda, M. R. (2014). Developing attention and self-regulation in childhood. In: A. C. Nobre & S. Kastner (Eds.), *The Oxford Handbook of Attention* (pp. 541-569). New York: Oxford University Press.

Prenger, R., Poortman, C. L., & Handelzalts, A. (2019). The effects of networked professional learning communities. *Journal of Teacher Education, 70*, 441-452. doi:10.1177/0022487117753574

Putnam, A. L., Nestojko, J. F., & Roediger, H. L., III. (2017). Improving student learning. In J. C. Horvath, J. M. Lodge, & J. Hattie (Eds.), *From the Laboratory to the Classroom: Translating Science of Learning for Teachers* (pp. 94-121-93). New York, NY: Routledge.

Raphael, T. E., Vasquez, J. M., Fortune, A. J., Gavelek, J. R., & Au, K. H. (2014). Sociocultural approaches to professional development: Supporting sustainable school change. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Bauserman (Eds.), *Handbook of professional development in education: Successful models and practices, PreK–12* (pp. 145–173). New York, NY: Guilford Press.

Repko, A. (2008). Assessing interdisciplinary learning outcomes. *Academic Exchange Quarterly, 12*, 171-178. Retrieved from https://oakland.edu/Assets/upload/docs/AIS/Assessing_Interdisiplinary_Learning_Outcomes_(Allen_F._Repko).pdf

Rodriguez, A., & McGuire, K. M. (2019). More classes, more access? Understanding the effects of course offerings on Black-White gaps in Advanced Placement course-taking. *The Review of Higher Education, 42*, 641-679. doi:10.1353/rhe.2019.0010

Roediger, H.L. III, Agarwal, P.K., McDaniel, M.A., & McDermott, K.B. (2011). Test-enhanced learning in the classroom: Long-term improvements from quizzing. *Journal of Experimental Psychology: Applied, 17*, 382-395. doi:10.1037/a0026252

Roediger, H. L., III, & Butler, A. C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences, 15*, 20–27. doi:10.1016/j.tics.2010.09.003

Roediger, H. L., III, & Karpicke, J. D. (2006). Test-enhanced learning. *Psychological Science, 17*, 249–255. doi:10.1111/j.1467-9280.2006.01693.x

Roediger, H. L., III, & Pyc, M. A. (2012). Inexpensive techniques to improve education: Applying cognitive psychology to enhance educational practice. *Journal of Applied Research in Memory and Cognition, 1*, 242-248. doi:10.1016/j.jarmac.2012.09.002

Rohlwing, R. L., & Spelman, M. (2014). Characteristics of adult learning: Implications for the design and implementation of professional development programs. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Bauserman (Eds.), *Handbook of professional development in education: Successful models and practices, PreK–12* (pp. 231–245). New York, NY: Guilford Press.

Rothschild, E. (1999). Four decades of the Advanced Placement program. *The History Teacher, 32*, 175-206. Retrieved from http://www.jstor.org/stable/494439

Rowland, M., & Shircliffe, B. (2016). Confronting the "Acid Test: Educators' perspectives on expanding access to Advanced Placement at a diverse Florida high school. *Peabody Journal of Education, 91*, 404-420. doi:10.1080/0161956X.2016.1184947

Ryu, M. (2015). Positionings of racial, ethnic, and linguistic minority students in high school biology class: Implications for science education in diverse classrooms. *Journal of Research in Science Teaching*, *52*(3), 347-370. doi:10.1002/tea.21194

Sadler, P. M., Sonnert, G., Tai, R., & Klopfenstein, K. (2010). *AP: A critical examination of the Advanced Placement Program*. Cambridge, MA: Harvard Education Press.

Sadler, P. M., & Tai, R. H. (2007). Advanced Placement exam scores as a predictor of performance in introductory college biology, chemistry, and physics courses. *Science Educator, 16*(2), 1-19. Retrieved from https://files.eric.ed.gov/fulltext/EJ783418.pdf

Savage, J. (2011). *Cross-curricular teaching and learning in the secondary school*. New York, NY: Routledge.

Saye, J. (2017). Disciplined inquiry in social studies classrooms. In Manfra, M., & Bolick, C. (Eds.), *The Wiley Handbook of Social Studies Research* (pp. 336-359). West Sussex, United Kingdom: John Wiley & Sons, Inc.

Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014). Effects of the flipped classroom model on student performance for Advanced Placement high school chemistry students. *Journal of Chemical Education, 91*, 1334-1339. doi:10.1021/ed400868x

Shadish, W., Cook, T., & Campbell, D. (2002). *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston, MA: Houghton Mifflin.

Shaunessy-Dedrick, E., Suldo, S. M., Roth, R. A., & Fefer, S. A. (2015). Students' perceptions of factors that contribute to risk and success in accelerated high school courses. *The High School Journal, 98*, 109-137. doi:10.1353.hsj.2015.0002

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*, 63-75. Retrieved from http://www.iospress.nl

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. doi:10.3102/0013189X015002004

Smith, J., Hurwitz, M., & Avery, C. (2017). Giving college credit where it is due: Advanced Placement exam scores and college outcome. *Journal of Labor Economics, 35*, 67-147. doi:10.1086/687568

Soloranzo, D. G., & Ornelas, A. (2004). A critical race analysis of Latina/o and African American Advanced Placement enrollment in public high schools. *The High School Journal, 87*, 15-26. doi:10.1353/hsj.2004.0003

Stanton-Salazar, R. D. (1997). A social capital framework for understanding the socialization of racial minority children and youths. *Harvard Education Review, 67*(1), 1–40. doi:10.17763/haer.67.1.140676g74018u73k

Swan Dagen, A. S., & Bean, R. M. (2014). High-quality research-based professional development: An essential for enhancing high-quality teaching. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Basuerman (Eds.), *Handbook of professional development in education: Successful models and practices, PreK–12* (pp. 42–63). New York, NY: Guilford Press.

Stufflebeam, D. L. (2003). The CIPP model for evaluation. In D.L. Stufflebeam & T. Kellaghan (Eds.), *The international handbook of evaluation* (pp. 31-61). Boston, MA: Kluwer Academic Publishers.

Suldo, S. M., Shaunessy-Dedrick, E., Ferron, J., & Dedrick, R. F. (2018). Predictors of success among high school students in Advanced Placement and International Baccalaureate programs. *Gifted Child Quarterly, 62*, 350-373. doi:10.1177/0016986218758443

Terry, N. B., de La Harpe, K., Kontur, F. J. (2016). The development of a learning gap between students with strong prerequisite skills and students with weak prerequisite skills. *Journal of College Science Teaching, 45*, 34-40. doi:10.2505/4/jcst16_045_03_34

Tschannen-Moran, M., & Chen, J. A. (2014). Focusing attention on beliefs about capability and knowledge in teachers' professional development. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Bauserman (Eds.), *Handbook of professional development in education: Successful models and practices,* PreK–12 (pp. 246–264). New York, NY: Guilford Press.

U.S. Department of Education. (2009). *American Recovery and Reinvestment Act of 2009: Using ARRA funds to drive school reform and improvement.* Washington, DC: U.S. Department of Education.

Vars, G. (1991). Integrated curriculum in historical perspective. *Educational Leadership, 49*, 14–15. Retrieved from http://middlegradescurriculum.yolasite.com/resources/Int.%20Curr.%20VARS.pdf

Vela, C. J., Lenz, A. S., Lerma, E., Fisk, J., Guardiola, R., & Cavazos, M. (2018). Exploring the relationship among teacher support, Advanced Placement coursework, and Latina/o students' college and vocational self-efficacy. *Journal of Latinos and Education*. doi:10.1080/15348431.2018.1531760

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (V. John-Steiner, M. Cole, S. Scribner, & E. Souberman, Trans.). Cambridge, MA: Harvard University Press.

Walker, J. (2016). *Brain-targeted early childhood beginnings: A case study*. (Doctoral dissertation). Retrieved from https://jscholarship.library.jhu.edu/handle/1774.2/40325

Walker, S. A., & Pearsall, L. D. (2012). Barriers to Advanced Placement for Latino students at the high-school level. *Roeper Review, 34*, 12-25. doi:10.1080/02783193.2012.627549

Warne, R. T., Larsen, R., Anderson, B., & Odasso, A. J. (2015). The impact of participation in the Advanced Placement program on students' college admission test scores. *The Journal of Educational Research, 108*, 400-416. doi:10.1080/00220671.2014.917253

Watt, K. M., Huerta, J., & Martinez, J. (2017). A mixed methods examination of gender disparity in high schools implementing advancement via individual determination (AVID). *Educational Studies, 53*, 377-389. doi:10.1080/00131946.2017.1335203

Weis, L., & Cipollone, K. (2013). 'Class work': Producing privilege and social mobility in elite US secondary schools. *British Journal of Sociology of Education, 34*, 701-722. doi:10.1080/01425692.2013.816037

Yan, V. X., Clark, C. M., & Bjork, R. A. (2017). Memory and metamemory considerations in the instruction of human beings revisited. In J. C. Horvath, J. M. Lodge, & J. Hattie (Eds.), *From the Laboratory to the Classroom: Translating Science of Learning for Teachers* (pp. 61-78). New York, NY: Routledge.

Youngs, P., & Lane, J. (2014). Involving teachers in their own professional development. In L. E. Martin, S. Kragler, D. J. Quatroche, & K. L. Bauserman (Eds.), *Handbook of professional development in education: Successful models and practices, PreK–12* (pp. 284–303). New York, NY: Guilford Press.

Zarate, M. E., & Pachon, H. P. (2006). *Gaining or losing ground: Equity in offering Advanced Placement courses in California high schools, 1997–2003.* Los Angeles, CA: The Tomas Rivera Policy Institute.

Zhang, G., Zeller, N., Griffith, R., Metcalf, D., Williams, J., Shea, C., & Misulis, K. (2011).

Using the context, input, process, and product evaluation model (CIPP) as a comprehensive framework to guide the planning, implementation, and assessment of service-learning programs. *Journal of Higher Education Outreach and Engagement, 15*(4), 57-83.

Appendix A

Research Summary Plan Matrix

Research question	Hypothesis	Research design	Data collection method	Data analysis method
1. How has overall AP enrollment changed annually from the 2014-2015 school year to the 2016-2017 school year?	AP enrollment will increase over the study period in schools where efforts to increase AP enrollment continue	**Setting**: 5 diverse schools in the district **Data:** Existing data from AP enrollment for each school in 2014-2015, 2015-2016, and 2016-2017	**Quantitative**: Existing data requested from district data warehouse through local IRB	**Quantitative:** -Descriptive statistics -Analyze measures of AP enrollment over the 3 years: -Percent change from prior year -Chi square test
2. How have AP exam scores changed annually from the 2014-2015 school year to the 2016-2017 school year?	AP exam scores will decrease over the study period in schools where rising numbers of AP students are not adequately prepared or supported	**Setting**: 5 diverse schools in the district **Data:** Existing data from AP exam score distribution for each school from 2015, 2016, and 2017	**Quantitative**: Existing data requested from district data warehouse through local IRB	**Quantitative:** -Descriptive statistics -Analyze measures of AP enrollment over the 3 years: -Percent change from prior year -Chi square test
3. What are AP teachers' and principals' perceptions of their students' ability to be successful in AP coursework, including in terms of self-efficacy, motivation, and prior knowledge?	AP teachers and principals will perceive AP students face challenges in AP courses due to limitations to self-efficacy, motivation, and especially prior knowledge	**Setting**: 5 diverse schools in the district **Participants:** 5 AP teachers (one per school) and 2 school principals of 2 of the target schools **Data:** Semi-structured interviews	Researcher-developed semi-structured interview questions for teachers (#2F, 3A, 3C, 4A) and principals (2D, 3A, 3C, 4B)	**Qualitative**: Identify a priori codes from defined constructs (self-efficacy, self-determination, motivation, prior knowledge) and identify emerging codes when analyzing transcripts (using Otter.ai)

4. How do AP teachers and principals describe their professional development preparation for teaching AP courses?	AP teachers benefit from engaging in valuable professional development specific to AP courses, such as the AP summer institutes, AP PLCs, and AP online forums	**Setting**: 5 diverse schools in the district **Participants:** 5 AP teachers (one per school) and 2 school principals of 2 of the target schools **Data:** Semi-structured interviews	Researcher-developed semi-structured interview questions for teachers (4F, 5C, 5D, 5E) and principals (5A, 5B, 5C)	**Qualitative**: Identify a priori codes from defined constructs (AP teacher background, professional development) and identify emerging codes when analyzing transcripts (using Otter.ai)
5. What instructional actions have teachers taken to address student success in AP coursework?	Teachers will have enacted innovative practices, sought professional development, focused some instruction on exam preparation, and facilitated study and review sessions	**Setting**: 5 diverse schools in the district **Participants:** 5 AP teachers (one per school) and 2 school principals of 2 of the target schools **Data:** Semi-structured interviews	Researcher-developed semi-structured interview questions for teachers (#3B, 4C, 4D, 4E, 5G) and principals (#3B, 4C, 4D, 5D)	**Qualitative**: Identify a priori codes from defined constructs (teacher practices, exam preparation, learning strategies) and identify emerging codes when analyzing transcripts (using Otter.ai)
6. To what degree are AP teachers in different content areas similar prepared to provide effective instruction for success in AP courses?	Teachers and principals will perceive innovative instructional practices (e.g., PBL, flipped lessons, inquiry-based lessons, student-centered lessons) as enhancing student success.	**Setting**: 5 diverse schools in the district **Participants:** 5 AP teachers (one per school) and 2 school principals of 2 of the target schools **Data:** Semi-structured interviews	Researcher-developed semi-structured interview questions for teachers (4B, 5A, 5F) and principals (4A, 5A)	**Qualitative**: Identify a priori codes from defined constructs (instructional practices, pedagogy) and identify emerging codes when analyzing transcripts (using NVivo or Otter.ai)

Appendix B

Instrument: Semi-Structured Interview Questions for AP Teachers

Introductory script

Hello, I am Tom Keller, and I am a teacher in the district. I am also a student in an Ed.D. program getting my doctorate, and in that capacity, I am conducting research that is related to your experiences in your professional context. There are no right or wrong answers to any of these questions; I am looking to better understand factors related to your context. To make sure I remember your responses with your permission I will be taking notes and audio recording this interview. The interview will take approximately 45-60 minutes. You can skip over any questions you do not wish to answer, and you can stop at any time. Before we get started, do you have any questions about the process?

Semi-structured interview questions for AP teachers

**Note: All of the following questions were used. Some of these questions are optional follow-up questions, and some of these questions may require additional probing questions.*

1. General/background
   - A. How long have you been teaching generally and more specifically teaching AP course(s)?
   - B. What AP course(s) have you taught?
   - C. What school(s) have you taught AP course(s)?
2. Perceptions of the AP program enrollment and exams
   - A. What changes have you noticed in your AP course enrollment numbers over time?
   - B. Has your school actively tried to increase AP enrollment?
     - i. What were your school's strategies to increase enrollment?
     - ii. If so, has AP enrollment actually increased?
     - iii. Have you noticed any effects of this increased AP enrollment on your classroom instruction?
   - C. How do you feel about efforts to increase AP enrollment?
   - D. What efforts has your school made to affect the number of students taking AP Exams?
     - i. Have these efforts had an impact on the number of AP Exams taken?
     - ii. How do you feel about efforts to affect the number of students taking AP Exams?
   - E. What changes have you noticed in your students' success on AP exams over time?
   - F. Are there prerequisites for enrolling in your school's AP courses (GPA, pre-test, coursework, etc.)?
     - o To what extent are all students in your school aware of these requirements and of how they can all gain access to AP courses?
3. Perceptions of AP students' preparedness
   - A. Over time, have you noticed changes in the academic preparedness of students in your AP courses?
     - i. What preparation or prior coursework do students in your AP course experience?
   - B. What components have you added to your AP courses over the years to support student success?

i. How do you know if students are successful?

C. What have you noticed about the characteristics of students who are successful in your school's AP courses or characteristics of students who are unsuccessful?

i. How have you adjusted your instructional practices to meet the needs of all students in your AP course?

4. Barriers

A. What skills or characteristics do you think are essential for student success in your AP course once they are in your class?

B. What are the biggest challenges you have noticed in helping students pass the AP exam?

i. How have you achieved success in overcoming these challenges?

C. Are you the only teacher of your AP content in your school?

i. What are the positives and negatives of that?

D. What interactions do you have with the teacher of the course students take just before your AP course?

E. How do you approach teaching an AP course differently from a non-AP course?

F. Do you believe your AP course adequately covers all the testable content on the AP Exam?

5. Supports

A. What supports would be most helpful for you to improve outcomes for all students in your AP courses?

B. What instructional practices do you find most successful in your AP course?

C. In teaching your AP course, what:

i. Resources have best supported you and your students

ii. Training has best supported you to prepare your students

D. Have you attended a College Board AP Institute?

E. Have you been a Reader for AP Exams?

F. Do you use items released from the College Board in your courses, such as practice AP Exams, previous student exam data analysis, etc.?

G. Who do you have opportunities to collaborate with?

Appendix C

Instrument: Semi-Structured Interview Questions for Principals

Introductory script

Hello, I am Tom Keller, and I am a teacher in the district. I am also a student in an Ed.D. program getting my doctorate, and in that capacity, I am conducting research that is related to your experiences in your professional context. There are no right or wrong answers to any of these questions; I am looking to better understand factors related to your context. To make sure I remember your responses with your permission I will be taking notes and audio recording this interview. The interview will take approximately 45-60 minutes. You can skip over any questions you do not wish to answer, and you can stop at any time. Before we get started, do you have any questions about the process?

Semi-structured interview questions for principals

**Note: All of the following questions will not be covered. Some of these questions are optional follow-up questions, and some of these questions may require additional probing questions.*

1. General/background
    - A. How long have you been a principal?
    - B. Have you ever taught an AP course?
2. Perceptions of the AP program
    - A. What changes have you noticed in your AP course enrollment numbers over time?
    - B. Over time, has your school actively tried to increase AP enrollment?
        - i. If so, has AP enrollment actually increased?
        - ii. Have you noticed any effects of this increased AP enrollment?
    - C. How do you feel about efforts to increase AP enrollment?
    - D. Are there prerequisites for enrolling in your schools AP courses (GPA, pre-test, coursework, etc.)?
        - i. Are all students in your school aware of these requirements and of how they can gain access to AP courses?
    - E. What changes have you noticed in your students' success on AP exams over time?
3. Perceptions of AP students
    - A. How does student preparedness for AP courses now compare to student preparedness 10 years ago?
        - i. Study skills, learning strategies, content background, motivation, efficacy?
        - ii. In what ways does prior coursework affect student performance once they enter AP courses?
            - a. If so, are you aware of any changes to instructional practices teachers have made to account for this?
                - 1. Were the changes successful?
    - B. Do you think AP teachers help teach students develop basic academic skills and learning strategies?
    - C. What have you noticed about the characteristics—or types of preparedness—of students who are successful in your school's AP courses?

4. Barriers
    A. What are the biggest challenges students in your school have with passing the AP exam?
        i. In what ways have teachers achieved success in overcoming these challenges?
    B. What basic academic or study skills do you think are essential for student success in your school's AP courses?
    C. What types of opportunities do AP teachers in your school have to collaborate with others?
    D. Have you noticed if teachers who teach both AP and non-AP courses approach teaching an AP course differently than a non-AP course? If so, in what way(s)?

5. Supports
    A. What supports do you believe would be most helpful for AP teachers in your school to improve outcomes for all students in your AP courses?
    B. Have AP teachers reported which:
        i. Resources have best supported them?
        ii. Training has best supported them?
        iii. Instructional strategies have best supported them?
    C. Do teachers in your school have an opportunity to attend the College Board AP Institutes?
    D. Who do AP teachers have opportunities to collaborate with?

Appendix D

Recruitment Email to AP Teachers

My name is Tom Keller and I am a doctoral student at Johns Hopkins University School of Education, and I am conducting research related to the Advanced Placement (AP) Program. I am emailing to request conducting a semi-structured interview with you. Ideal interviewees will have 5 or more years of experience teaching an AP course. The interview will last approximately 45-60 minutes and can be conducted over the phone or in person.

Please let me know if you are willing to participate in this research. Thank you for your consideration of this request, and I look forward to hearing from you.

Tom Keller

tkeller6@jh.edu

(410)693-0895

These materials are neither sponsored by nor endorsed by the Board of Education of Baltimore County, the Superintendent, or this school or office.

Appendix E

Recruitment Email to School Administrators

My name is Tom Keller and I am a doctoral student at Johns Hopkins University School of Education, and I am conducting research related to the Advanced Placement (AP) Program. I am emailing to request conducting a semi-structured interview with you. Ideal interviewees will have been the principal of your school for at least three years, and your school will have had a continually running AP Program for at least the past 10 years. The interview will last approximately 45-60 minutes and can be conducted over the phone or in person.

Please let me know if you are willing to participate in this research. Thank you for your consideration of this request, and I look forward to hearing from you.

Tom Keller

tkeller6@jh.edu

(410)693-0895

These materials are neither sponsored by nor endorsed by the Board of Education of Baltimore County, the Superintendent, or this school or office.

Appendix F

Needs Assessment Codebook

Theme	Code	Definition	Evidence
Efforts to increase AP enrollment	Recruit students	An active effort by schools and teachers to encourage increasing numbers of students to enroll in AP courses	We strongly encourage these kids to take AP classes, even though they quite weren't ready for the class (A) We have tried to increase enrollment in AP classes, some more than others (C) I started with one section, and I worked my way up to two sections. And I'm trying to recruit kids from all levels. And, you know, going through that diversity piece, And I don't know if we've really hit the mark on that. But I see a difference in the kids that I'm kind of recruiting, you know, they need...something. But I kind of thought it was important to make all the kids that take either living systems or back then bio, feel welcome to try to take it, right. And that may have hurt my test scores. (D) There has been a big push to increase enrollment. We go around, talk to students, talk to classes of all levels (E) Our goal here is to increase access...over the past five years, we've increased the number of test takers and tests given (F) When I was assistant principal, at one point, about 2007, the superintendent made an edict, every high school in [the district], that every high school would offer at least 13 AP course offerings. And so for the school that I was in at the time, that was not the case. So, we ended up, you know, putting these courses out there that we had not previously offered, trying to get teachers ready to deliver them, and then also trying to convince, you know, the school to push enrollment (F)
	Open access	A school action of removing prerequisites for AP courses as part of efforts to increase AP enrollment	If any student wants to take it they could (B) Years ago there were GPA requirements, no more (C) because they were not in a GT class, they may not have the same level of access to the program. What we're finding is that that eighth to ninth grade year is really an opportunity where we can identify some students who perhaps are going to be really pleased in that pipeline (F)

			There are NOT a lot of entry points that you tend to see through elementary and middle school. So, we really tried to kind of have a mindset of opening doors for kids who want to self-select in or getting a recommendation from the teacher (G)
	Lower-level classes	Standard and honors level courses, as opposed to the advanced academic track, gifted and talented (GT)	Branched out to the standard teachers to get students who typically wouldn't sign up for an AP course, and try to get them up to speed so they're not super unprepared (C) We try to find students in lower level classes who can be on an AP trajectory, regardless of their placement (F) Also, we have the opt in program, so you could have never had a GT English class, and you can select AP. Which again sounds great, inclusive, we're all for that, but again there is that gap [in prior knowledge] there (E)
	College admissions	The ways that the college admissions process influences student enrollment in AP courses	A certain group of students are choosing more AP classes, taking 4 or 5 AP, and that workload may contribute to a lack of success (E) A little over ten years ago, the College Board, really pushing in to the system and pushing into the classroom and AP courses became so much more of a higher stakes thing for college acceptance (F) Jockeying for position in class rank (F) "[There is] competition between [college] credit that the student could possibly get through [the community college]; they can matriculate, you know, into post-secondary as well (G)
	Unintended consequences	Unforeseen negative side effects of efforts to increase AP enrollment	I had AP classes of 4 kids…that was unintended consequences of increasing enrollment…that was something very difficult to maintain... with our resources continuing to dwindle, regardless of access, seven kids in the class or not, is not sometimes the wisest use of resource (F) The academic profile of AP courses has shifted, that's what we want to do…we want to shift all kids up a level. But we encountered problems [when] not everyone starts from the same spot (F) it's been very few times where I would say somebody in like a standard track has gone up to an AP track and been successful (B)
AP exam pass rates	Minimal emphasis	The relatively low level of importance placed on AP exam pass rates compared	Over the years, it's always been just about the enrollment numbers (A) No pressure from administration (B)

		to increasing AP enrollment	The best admin I ever worked for said, yes, I know the score is important, but I also know the experience of taking the exam is valuable for our students (C) The school wants the enrollment numbers, so we get high marks in that, but they also want the pass rate. It's not like there is a punitive side to it, but there is a judgement. (E) AP Exam scores is NOT my priority (F)
	Access misconception	A prevalent misconception in schools that mere exposure to AP courses will result in improved student outcomes	While they might not be like, A or B students, you know, they will benefit from taking a more rigorous, and in [*sic*] college level class to prepare them for college. (A) Access to that kind of curriculum has had a positive effect on the overall achievement of those kids (E) For us, it really is an exposure to that rigor and to that type of thing (F) Our philosophy is really about the experience of the AP class (G)
Differences in students' prior knowledge	Varying skill levels	The diverse range of academic skills demonstrated by AP students	This has kind of been the trend over the years, there's a lot of gaps in learning coming from the middle school and coming from early high school (A) A lot of them come in with varying ability levels, which was not the more traditional AP English classroom…for instance, we tested this year…scores ranged from 14-51 (out of 55 MC) within one single class. That wasn't the case several years ago (E) I didn't feel they had enough skills to be able to interpret and analyze authentic resources they were expected to know and complete on the AP exam (A) It's not motivation holding them back (D) Having motivation and drive to do a good job can help, sometimes it's not enough (A)
	Varying academic experiences	The diverse educational history experienced by AP students	They haven't always gotten a good education that should make them ready (C) Students who are not coming from a GT background tend to struggle in my [AP] course…they weren't taught the same skillset (E)

			You do need to have, you know, certain skills in order to be successful at the exam. Because there's so many gaps and differences in what they've learned (B) Last year there were teachers who said that they couldn't teach the proper curriculum, because some of the kids were behind (A)
	Teachers' mindset (regarding differences in student prior knowledge)	How teachers perceive the increasingly diverse academic profile of AP classes	My thinking may have been different several years ago, but I think our AP teachers have begun to shift from a mindset of a student needs to come in and be prepared and have all the skills necessary, as opposed to where we are going, which is meeting the students where they are and really having a similarly responsive mindset that you would have with a non-AP class (G) Our teachers have really said, we are going to recognize those gaps and we're going to find ways to close them, as opposed to, say, a student has a gap in their learning or skill and they're therefore not appropriate for AP (F)
	Content-specific test-taking skills	Skills students may apply to improve success on disciplinary assessments	You really have to teach them how to take the exam (D) I'm learning with the kids so learning what works and what doesn't work and what they need to focus on more. It allowed me and my students to get better at taking the exam (B) There's not enough time in the day that I can teach them all the vocabulary that they can actually see in the exam. So a lot of the skills that they need, is being able to interpret and using what they know to different applications, to be able to and understand either a text and audio. And then of course transition that to be able to write, and then be able to speak about it (A)
	Teaching introductory courses	Opportunity to groom students for AP because the teacher knows what skills and knowledge are needed for AP	So it starts right from the beginning of first year that I had them as a freshman or sophomores and building those skills that I knew they needed to be able to analyze text and be able to interpret audio (A) When those students that I taught in the freshman year, come back to me as juniors and seniors like that, it's just fabulous, because first of all, I know what they know, or should know, right? Because I taught them (D) You understand what they need for AP (B)

			You can kind of more easily identify if those students are ready for AP and what they need…what you need to get to them in terms of content knowledge and skills (B) When I teach GT Biology, the feeder to APES and AP Bio, I can create a pipeline (C) We really tried to create an AP program as a school as where I think previously we've really been looking at it departmentally. So English was doing one thing, SS may be doing another, but recently, looking at recruitment and retention as a whole school. We really tried to create what we call an AP community so students are really feeling that the part of a pipeline or part of our program really starting in the summer prior to ninth grade (G)
	Studying strategies	Skills and techniques students apply to enhancing learning, memory, and transfer	How to study and how to take notes (B) In the past two years, I've become more aware of student needs in terms of needing to learn how to study. I used to have this assumption that they knew what they were doing already, and that was incorrect. (B) They don't know how to study (A) When you say study, they don't necessarily know what that means (C) How they should figure out the best way to study (D) They need assistance with those kind of skills, those are key to keeping the students on track. We don't have time to teach those skills…but they need that (E) Contrastingly… I think there is time, if you can integrate those things into what you're already doing (C)
Collaboration	Negative experiences	Previous ineffective collaboration with colleagues	I've had a few teachers over the years, I was able to collaborate with, but was never a great experience...I would love to find someone who was willing to collaborate and share (A) I've worked with people in the past who did not want to collaborate (E) My first year, there was another teacher teaching AP Biology, but we didn't collaborate or bond much (C)

	Isolation	The sense of having limited collaboration opportunities due to being the only content-specific AP teacher in a school	I've been the only [AP] World History teacher at [my school] for many years (D) It is isolating, I don't have anyone to bounce ideas off of (C) Insufficient opportunities for collaboration (B) We need to better diversify our portfolio of AP teachers…need to get more teachers involved in teaching AP courses. Having more than one person, natural collaboration could exist (F)
	Vertical teaming	Collaboration among teachers of various grade levels, which can align content, expectations, skills, and knowledge for students as they progress through grade levels	New this year, four times a year, we are vertical teaming with all the high school and middle schools in our region (A) Vertical teaming is extremely important, and it's probably less common than grade-level teaming (E) Have gone down to the middle school or a little bit of vertical alignment (B) Helps the middle school teachers understand what students will need once they get to AP classes in high school (B) Collaborating back with that ninth-grade teacher (G) We're lucky because we're in the same building as the middle school (G)
Professional Learning	Advanced Placement Summer Institute (APSI)	A week-long, intensive summer training program sponsored by the College Board to prepare teachers for instructing specific AP content area courses	I've done that summer institute...and that's great, especially as a new AP teacher, going and not only learning about the exam itself but getting a lot of resources from those who are in the class as well as the professor. The teacher provided a lot of the textbooks that are offered as samples (A) So valuable…I learned so much from that (C) I don't think I could have taught the course, like I would have gone in, you know, quaking in my boots, if I hadn't taken that course...I think it might be more useful to have like, even every couple of years, an institute that like, you know, an update or brush up, here's what's new, you know, I would love to retake the institute, quite frankly (D)

			The district is pretty keen on sending you if you're a first timer, but after that, it's too expensive (D) We don't have the ability to send a number of teachers to the summer institute (F)
	Advanced Placement Teacher Community (APTC)	An online resource available to all AP teachers, which provides opportunities for collaboration through online discussion boards and resource sharing	College Board online collaboration, this is the first summer that I actually took a look at it. And some things are good, some things are not so good. It really just depends on who's posting it (A) I find it cumbersome (C) I don't find the time to use the online forum, it's daunting (E) My teachers will tell me the most valuable experience for them is grading AP exams and really seeing firsthand the quality of work that is expected on that exam and then really using that to be able to backwards map their instruction. So, we've had several instructors be able to participate in that experience, and they have found that to be incredibly valuable (G)
	Professional learning community (PLC)	A group of educators who collaborate regularly to share expertise and work to improve teaching skills and student outcomes	Sharing of data and best practices, and just providing time, whether it's the whole school, or all social studies, or breaking it down, you know even more specifically, would be huge (G) For the first time this year, the AP science teachers have common planning time, which is amazing. (B) We have a PLC now, it's departmental, but we don't really do much. I'd much rather be able to collaborate with other AP teachers in the school (E)
	Positive deviants	AP teachers whose behaviors result in substantially better outcomes compared to similar peers	Lead to conversations…what do you do in the classroom that is leading to success? I think there is value in knowing that…there should not be shame in scores… (C) It could be valuable if you take into account all the variables, which is hard to do (E) If we could use those people for PD and they'd be willing, then that would be great (E) Absolutely. It has to be a very careful process. But like any piece of data. There is a lot to be learned from it, particularly when you really break that data down. And you can look at it year after year as well. You know, we share that as a leadership team, we all meet with each individual teacher and go over strengths and challenges. And certainly, from a school system level it would be interesting to see, you know, where is there a subject area where there's, you know, a lot of

			success being experienced and, you know, it's about a master teacher who can help out with a newer AP teacher. There's a large benefit to sharing that data
Instructional strategies	Inquiry-based learning	A form of student-centered, active learning in which students often pose questions, solve problems, and construct their own learning (e.g., project-based lessons and flipped lessons)	I know I should use more student-centered lessons and less lecture, but I don't know how to create those kinds of lessons given my time constraints (B) Some [AP teachers] use flipped lessons, but I haven't taken that leap yet (C) The social studies department has shifted their AP courses toward project-based activities, it's been challenging for them to adjust, teachers and students, really (E)
	Focused immediate preparation	Summer training programs designed to prepare incoming AP students for the rigorous coursework and expectations of their upcoming AP course	Primarily to establish a level of expectations for AP… We offer a bridge program in the summer, where basically, it's an exposure to different strategies to help manage, things like organization, like note-taking. Like before maybe getting a jump on the actual curriculum, it's really just kind of teaching and kind of exposing the rigor of what needs to happen in order to be successful (F) So, we did a prep and AP boot camp over the summer with some of those students [new to advanced coursework] and then some of our students who took AP courses previously, who could return and provide them with additional support they may need going into the next school year (G) We've tried a summer program for a week while expanding AP enrollment. Worked together to generate some organization skills, team building, content activities, to help kids who have stepped up to take the class feel more comfortable and confident (C) So just like mindset shift, it's really hard to quantify (F)

Appendix G

Initial Logic Model for the AP PLC

Situation: An AP PLC could provide AP teachers with collaborative opportunities and enhanced knowledge and self-efficacy to incorporate retrieval practice learning and studying strategies in their courses, which could better prepare AP students for success in the course and on AP exams

Inputs

Time: 90 minutes of initial PL & 30 minutes weekly (after school) for 12 consecutive weeks
Space: All PL will occur in researcher's classroom
Materials:
-Recruiting flyer
-Anchor chart of strategies x28
-Summarized evidence from literature
-Equipment to model strategies (e.g., projectors, document camera)
Partnership:
-Principal
-School-based PL Leader
Funding:
-Snacks for sessions
-Materials for anchor charts and handouts
Lessons: AP teachers bring lesson parts to collaborate with and develop

Outputs

Activities

Phase 1: 90-minute session (9/3/20)
-Rationale, goals, and norms for the AP PLC
-Misconceptions about optimal learning and studying strategies
-Preview retrieval practice strategies to build durable learning

Phase 2: Weekly 30-minute sessions (9/9/20-11/11/20)

First 15 minutes: New Learning Content	**Last 15 minutes: Supported Collaboration**
A) Quick Google survey reporting 'use of' strategies from past week	**A)** Identify to what extent teachers currently use retrieval practice in their class
B) Misconceptions about learning and studying	**B)** Identify places in lessons to incorporate retrieval practice
C) Evidence that supports retrieval practice as enhanced learning and studying strategies for durable learning	**C)** Collaborate to enhance incorporation of retrieval practice (using samples or ideas of lesson components that they bring)
D) Model basic classroom applications of effective retrieval practice	**D)** Identify places in lessons they can provide opportunities in class to model how to effectively use retrieval practice when studying on their own
E) Model advanced classroom applications of effective retrieval practice	**E)** Share positive and negative experiences of integrating retrieval practice to arrive at "best practices"
F) Explain and model techniques to help students use retrieval practice when studying on their own	**F)** Develop a plan for how to sustain employing retrieval practice strategies moving forward
G) Review and summary	

Participation

Treatment: All AP teachers at RHS (N = 28) may volunteer participate in all 13 AP PLC sessions

Control: All AP teachers (N = 28) at a similar high school in the district; business as usual

Deliverable Outputs
-AP teachers leave weekly with a lesson elements developed that incorporate retrieval practice strategies
-13 session plans that align with the PL sessions (i.e., evidence from literature, presentation slides, models)

Outcomes

Short

Improved AP teacher knowledge of effective retrieval practice learning and studying strategies

Improved teacher self-efficacy for teaching effective retrieval practice learning and studying strategies

Medium

Increased classroom application, modeling, and encouragement of strategies by AP teachers

AP students enhance their learning and studying methods

Improved student performance in AP courses

Long

Improved AP exam scores and associated benefits

Assumptions
-AP teachers will have a growth mindset (Dweck, 2006) and willingly engage in PL
-AP teachers will incorporate the retrieval practice strategies in their lessons
-AP teachers will be willing to self-report 'use of' strategies and collect student data (i.e., deidentified aggregate mean course exam scores from select units)
-13 weeks is adequate time to positively influence AP teachers' knowledge and self-efficacy for implementing and teaching effective retrieval practice strategies

External Factors
-Other school initiatives in the School Progress Plan may not align with this PL plan logistically
-Regularity of after school meetings may lead to attrition of participants
-Maturation in AP teachers and students may occur over time

Appendix H

Data Collection Matrix for Process and Outcome Evaluations of the AP PLC

Process Evaluation Question	Process Evaluation Component & Indicator	Data Sources	Data Collection Tool	Frequency & Responsibility	Data Analysis
1) How did AP teachers describe their experience in the AP PLC?	**Component**: AP PLC Implementa-tion **Indicator**: AP teachers' perceptions of the meaningfulness of the AP PLC	22 AP teacher participants in the AP PLC	**Quan**: **Process Evaluation Survey (PES)** (Appendix I; Likert, rate specific aspects of the program) e.g., I can apply the strategies to my AP course	The student researcher will conduct a combined Qual and Quan survey three times; after weeks 4, 8, and 13 of the 13-week program	**Descriptive statistics** and **ANOVA** to examine differences over time
	Component: Participant responsiveness **Indicator**: AP teachers' level of engagement in the AP PLC	22 AP teacher participants in the AP PLC	**Qual**: **Process Evaluation Survey (PES)** (Appendix I; Open-ended survey questions) e.g., Briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was engaging for you		**Deductive coding** for a priori codes (e.g., modeling, collaboration); **inductive coding** to allow additional codes to emerge
		1 participant per week	**Qual**: Document Analysis for Deliverable Outputs of the AP PLC (Photodocument teacher-created lesson elements each AP PLC session)		**Deductive coding** for a priori codes (e.g., modeling, collaboration); **inductive coding** to allow additional codes to emerge
		22 participants	**Quan**: Attendance Log of the AP PLC		**Descriptive statistics**

Outcome Evaluation Question Or Variable	Construct	Data Sources	Data Collection Tool	Frequency & Responsibility	Data Analysis
2) To what extent did AP teachers' knowledge and self-efficacy of retrieval practice strategies increase in response to the AP PLC compared to a control group?	Teacher knowledge of retrieval practice strategies	35 AP teachers in both the treatment and control groups	**Quan**: **Outcome Evaluation Survey (OES)** (Appendix L; Likert scale, adapted from existing surveys) e.g., Repeatedly rereading information describes retrieval practice	Survey will be conducted by the student researcher pre- and post- the intervention	**Descriptive statistics** and **repeated measures ANOVA and t-tests** to examine differences over time
	Teacher self-efficacy to implement retrieval practice strategies	5 AP teachers	**Qual: Semi-structured interviews** (Appendix M) e.g., How has the AP PLC changed your understanding of what retrieval practice learning and studying strategies are?	Once, after the intervention	**Deductive coding** for a priori codes (e.g., spacing, interleaving); **inductive coding** to allow additional codes to emerge
3) To what extent did AP teachers increase their use of retrieval practice strategies in their AP classes as a result of the AP PLC?	Frequency of 'use of' strategies	22 AP Teachers	**Quan**: **Frequency of Use Survey (FUS)** (1-item survey) e.g., How many times do you use retrieval practice strategies in your AP class during the past week?	Weekly (at the beginning of each session regarding the previous week's implementation)	**Descriptive statistics** and **Pearson's correlation** to examine differences over time
4) What are AP teachers' perceptions of how well students are prepared for success in	Teachers' perceptions of effective-ness of	35 total AP Teachers	**Quan**: **Outcome Evaluation Survey (OES)** (Appendix L; Likert scale) e.g., My AP students are well prepared for AP exams	Survey will be conducted by the student researcher pre- and post- the intervention	**Descriptive statistics** and **repeated measures ANOVA and t-tests** to

AP courses after the AP PLC compared to a control group?	strategies for AP students				examine differences over time
		5 AP Teachers	**Qual: Semi-structured interviews** (Appendix M) e.g., How has the AP PLC prepared you to help all your AP students be better prepared for AP coursework?	Once, after the intervention	**Deductive coding** for a priori codes (e.g., spacing, interleaving); **inductive coding** to allow additional codes to emerge
5) What is the difference between AP students' unit test scores before and after their teachers participated in the AP PLC compared to a control group?	Student academic outcomes in the AP course	Existing and Current Aggregated Mean Data from 35 total AP teachers	**Quan**: Select aggregate course mean unit exam scores from December 2019 (pre-intervention), September 2020 (pre-intervention) and Fall 2020 (post-intervention)	Student research will collect this data once after the intervention (reported by AP teacher participants)	**Descriptive statistics** and **independent samples t-tests** to examine differences over time
Potential Moderating Variable	Years of teaching experience	35 total AP Teachers	**Quan: Researcher-created survey** e.g., For how many years have you been a teacher?	Once, after the intervention	**Descriptive statistics**
Potential Moderating Variable	Years of teaching an AP course	35 total AP Teachers	**Quan: Researcher-created survey** e.g., For how many years have you been an AP teacher?	Once, after the intervention	**Descriptive statistics**

Appendix I

Process Evaluation Survey (PES)

Participants: Treatment group only
Frequency: After weeks 4, 8, and 13 of the AP PLC

Process Evaluation Research Question: How did AP teachers describe their experience in the AP PLC?

Scale: AP teachers' experiences in the AP PLC

Items #1-6 are on a rating scale:

1 – Strongly disagree
2 – Moderately disagree
3 – Disagree slightly more than agree
4 – Agree slightly more than disagree
5 – Moderately agree
6 – Strongly agree

Subscale: Meaningfulness of the AP PLC

The term "**strategies**" in following 6 statements refers to the **retrieval practice strategies presented in the AP PLC**.

1) I can apply the strategies to my AP course.
2) The strategies can help my AP students be successful in my course.
3) The research evidence for using the strategies helped me understand how to apply these strategies in my AP course.
4) The modeling of the strategies helped me understand how to apply these strategies in my AP course.
5) The collaboration with colleagues helped me understand how to apply the strategies in my AP course.
6) The coaching support provided by the professional learning leader helped me to transfer the strategies to use in my AP course.

Items #7 and 8 are open ended questions:

7) Briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was meaningful for you to use in your AP class. ___________________________
8) Briefly describe how the **collaborative activities** in the AP PLC were meaningful for you to use in your AP class. _________________________________

Subscale: Engagement in the AP PLC

The following 5 statements refer to your engagement **during the AP PLC**.

1) I was engaged in the presentation of research evidence for using retrieval practice strategies.
2) I was engaged in the modeling of retrieval practice strategies.
3) I was engaged in the collaborative activities.
4) I was engaged in the coaching provided by the professional learning leader.
5) I engaged in developing lesson elements for my AP course that incorporated retrieval practice strategies.

Items # 6 and 7 are open-ended questions:

6) Briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was engaging for you. ________________

7) Briefly describe how the **collaborative activities** in the AP PLC were engaging for you. ___________________________________

Subscale: Moderating Variable Data

(**Only included on the FIRST of three PES administered**)

1) How many total years of experience do you have as a classroom teacher/general educator? ____
2) How many total years of experience do you have teaching an AP course(s)? ___

Appendix J

Participant Recruitment Email for Potential Participants in the AP PLC

My name is Thomas Keller and I am a doctoral student at Johns Hopkins University School of Education, and I am conducting research related to enhancing AP student learning. I am emailing to request your voluntary participation in the AP Professional Learning Community (AP PLC) featuring retrieval practice learning strategies. Participants will need to be full-time, certified teachers at Hereford High School who are assigned to teach at least one AP course during the 2020-2021 school year. The AP PLC will meet weekly for 13 times, beginning September 2, 2020 at Hereford High School. The first session will last approximately 90 minutes, followed by 30-minute sessions that involve new learning about retrieval practice strategies and collaborative time to develop ready-to-use lesson components for your AP courses that are specifically designed to enhance student learning and studying strategies. Bodies of evidence suggest these strategies and the AP PLC may help improve student outcomes.

Please let me know if you are willing to participate in this research. Thank you for your consideration of this request, and I look forward to hearing from you.

Tom Keller
tkeller6@jh.edu
(410)693-0895

These materials are neither sponsored by nor endorsed by the Board of Education of Baltimore County, the Superintendent, or this school or office.

Appendix K

Participant Demographic Data Survey (DDS)

Participants: Treatment group

Frequency: post AP PLC

1) Select your race(s).
    a. American Indian/Native Alaskan
    b. Asian
    c. Black
    d. Hispanic
    e. Native Hawaiian or Other Pacific Islander
    f. White
    g. Other
    h. Prefer not to answer
2) Select your gender.
    a. Female
    b. Male
    c. Other
    d. Prefer not to answer
3) Which AP course(s) do you currently teach? ______________

Appendix L

Outcome Evaluation Survey (OES)

Frequency: pre- and post- intervention
Participants: Treatment and control groups

Outcome Evaluation Research Question 1: To what extent did AP teachers' knowledge and self-efficacy of retrieval practice strategies increase in response to the AP PLC compared to a control group?

Scale: **AP teachers' knowledge of retrieval practice strategies**

Subscale: Definitional knowledge of retrieval practice strategies

Determine whether each of the following items is True or False:

1) Repeatedly rereading information describes retrieval practice.
2) Massed practice is when students study together.
3) Recalling information from memory describes retrieval practice.
4) Spaced practice is studying in short episodes over several days.
5) Mixing up the types of problems to be solved describes interleaving practice.
6) Repeatedly relistening to information describes retrieval practice.
7) Massed practice is cramming for a test.
8) Studying one concept before moving on to the next concept is interleaving practice.
9) Providing feedback to a learner immediately after completing a task enhances durable learning.
10) Spaced practice is when students study independently.
11) Studying in a way that is difficult but manageable can enhance durable learning.
12) Providing feedback to a learner a couple of days after completing a task enhances durable learning.
13) Studying in a way that is difficult but manageable can make learning more flexible so it can be applied to other situations.
14) Massed practice enhances durable learning.
15) Interleaving practice enhances durable learning.

Subscale: Knowledge of instructional activities that evoke retrieval practice in students

For each instructional behavior, determine whether the teacher employs a retrieval practice strategy. (True or False)

1) Providing students with immediate feedback following a quiz supports students' durable learning more than providing students with feedback two days after the quiz.
2) Providing students with groups of similar problems during a unit review promotes more effective retrieval practice than mixing up types of problems during a unit review.
3) Periodically reviewing content over time offers more effective retrieval practice for students than reviewing content all at one time.
4) Encouraging students to highlight notes and text provides students with opportunities for effective retrieval practice.
5) Playing a review game requiring recall (e.g., Kahoot! or Quizlet) provides students with opportunities for effective retrieval practice.

Subscale: Knowledge of how retrieval practice appears in classroom activities

For each classroom scenario, determine whether the teacher employs a retrieval practice strategy. (True or False)

1) At the end of a lesson, a teacher asks students to review content learned during the day's lesson by using their notes to answer summary questions.
2) At the beginning of a lesson, a teacher asks students to perform a think-pair-share activity (i.e., students think individually for two minutes without using resources, discuss with a partner for 2 minutes, then have a whole group discussion) to review the previous day's content.
3) A teacher asks students to review for a unit exam by having student use their notes and textbook to create a mindmap (i.e., concept map or graphic organizer).
4) A teacher tells students that all quizzes within a unit are cumulative (i.e., each quiz includes some content from previous quizzes).
5) A teacher asks students to review for a unit exam by making flashcards and using them to study by quizzing themselves.

Scale: **<u>AP teachers' self-efficacy of using retrieval practice strategies</u>**

All of the following items are on a rating scale:

1 – Strongly disagree
2 – Moderately disagree
3 – Disagree slightly more than agree
4 – Agree slightly more than disagree
5 – Moderately agree
6 – Strongly agree

Subscale: Employ instructional activities that promote retrieval practice

1) I can create questions that promote retrieval practice to begin a lesson (i.e., warm-up, drill).
2) I can create questions that promote retrieval practice to end a lesson (i.e., exit ticket, summary, review)
3) I can create quiz questions throughout a unit that encourage students to perform effective retrieval practice.
4) I can design review activities for students prior to a unit exam that encourage students to perform effective retrieval practice.

Subscale: Employ instructional activities that optimize retrieval practice with complementary strategies

1) I can develop class activities that space out the review of important content over time.
2) I can develop class activities that mix up different types of problems during the review of important content.
3) I can provide meaningful feedback to students one or two class periods after students complete the assignment.
4) I can develop class activities that provide students with opportunities to review important content that are challenging, but not too challenging.

Subscale: Encourage students to use retrieval practice strategies when studying on their own

1) I can model for students how to use retrieval practice strategies when studying on their own.
2) I can prompt students to use retrieval practice strategies when studying on their own.
3) I can address questions students may have about how to use retrieval practice strategies when studying on their own.
4) I can explain to students why using retrieval practice strategies when studying on their own may produce durable learning.

Outcome Evaluation Research Question 3: What are AP teachers' perceptions of how well students are prepared for success in AP courses after the AP PLC compared to a control group?

Scale: **AP teachers' perceptions of student preparedness for AP coursework**

All of the following items are on a rating scale:
1 – Strongly disagree
2 – Moderately disagree
3 – Disagree slightly more than agree
4 – Agree slightly more than disagree
5 – Moderately agree
6 – Strongly agree

Subscale: AP teachers' perceptions of AP students' repertoire of learning and studying strategies

1) My AP students possess effective learning strategies.
2) My AP students employ effective learning strategies.
3) My AP students possess effective studying strategies.
4) My AP students employ effective studying strategies.
5) My AP students can transfer knowledge to different situations.

Subscale: AP teachers' perceptions of AP students' preparation for academic success

1) My AP students can thoroughly understand complex content.
2) My AP students believe they can do well in my AP course.
3) My AP students are well prepared for AP coursework.
4) My AP students are well prepared for AP exams.
5) My AP students are well prepared for future rigorous courses.

Appendix M

Semi-Structured Interview Protocol

Participants: Treatment group only

Semi-structured interview questions for Research Question 2: To what extent did AP teachers' knowledge and self-efficacy of retrieval practice strategies increase in response to the AP PLC compared to a control group?

1) How has the AP PLC changed your understanding of what retrieval practice learning and studying strategies are?
    a. What do you know now that you did not know prior to the AP PLC?
2) How has the AP PLC changed your understanding of how to design instructional activities to promote students to use retrieval practice?
3) How has the AP PLC changed your understanding of what it looks like when students use retrieval practice strategies?

4) How has the AP PLC changed your ability to use instructional activities that promote retrieval practice strategies in your AP class?
5) How has the AP PLC changed your ability to use instructional activities that optimize retrieval practice strategies by using complementary strategies, such as spacing practice, interleaving practice, and providing delayed feedback, in your AP class?
6) How has the AP PLC changed your ability to prompt students' use retrieval practice strategies when studying on their own?

Semi-structured interview questions for Research Question 4: How are students prepared for success in AP courses after learning retrieval practice strategies?

1) How has the AP PLC changed your understanding of the value of retrieval practice strategies to promote student learning?
2) How has the AP PLC prepared you to help all your AP students be better prepared for:
    a. AP coursework?
    b. AP exams?
    c. Future rigorous courses?
3) How has the AP PLC prepared you to help all your AP students develop satisfactory study strategies?

Appendix N

Frequency of Use of Survey (FUS)

Participants: Treatment group only

Frequency: Weekly

Outcome Evaluation Research Question 2: To what extent did AP teachers increase their use of retrieval practice strategies in their AP classes as a result of the AP PLC?

Scale: AP teachers' frequency of using the strategies in their AP course

Short Qualtrics Form:

If you teach more than one AP course or more than one section of an AP course, **choose only specific AP class section** to answer these items.

1) The number of times I used retrieval practice strategies in my AP course during the past week was _____

Appendix O

Process Evaluation Codebook

Open-ended survey item prompt	Theme	Definition	Example
Briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was meaningful for you to use in your AP class	Modeling	The presenter's demonstration of a new concept or strategy by imitating that concept or strategies during instruction	"[The presenter] did a great job at modeling the retrieval practices that we were learning about throughout the presentations." (Participant B)
	Research	Evidence from research presented during the AP PLC that supports teachers' use of the strategies	"It was helpful to gain a full understanding including the research behind the ideas presented." (Participant S)
	Accessible	The ability for concepts or strategies to be readily obtained by participants due to the structure of the learning activities	"[The presenter] really broke the process down and the reasoning/explanation of the process and made it very easy to understand and use." (Participant I)
	Transformative	A fundamental change in teachers' perspectives on effective learning or teaching	"It helped me learn how to reevaluate the process of learning and reach a broader range of students in my class." (Participant P)
	Limitations	Factors that minimize the potential meaningfulness of the AP PLC	"My AP class is very much application-based. There is little vocabulary or similarly basic conceptual matter that would work with flash cards." (Participant D)

Briefly describe how the **collaborative activities** in the AP PLC were meaningful for you to use in your AP class	Sharing ideas	The collaborative exchange of instructional strategies and practices, which evoke retrieval in students, among participants	"Other teachers shared ideas that I can adapt for my own AP class." (Participant E)
	Reflection	Reconsideration of one's own practices informed by discussions of successes and challenges among colleagues	"I appreciated hearing other teachers [*sic*] successes and failures because it allowed me to feel that I am not alone in my struggles and also garner new ideas for my own classroom." (Participant I)
Briefly describe how the **presentation** of retrieval practice strategies in the AP PLC was engaging for you	Interactive	The structure of the AP PLC allowed for active learning and dynamic participation	"There was a good discussion through the chat and with mics." (Participant V)
	Applicability	The characteristic of information and strategies that could readily be used in participants' AP courses	"The real class application piece got my attention and I appreciated that we tested the feature (student side) and got to see the teacher side." (Participant I)
	Modeling	The presenter's demonstration of a new concept or strategy by imitating that concept or strategies during instruction	"Modeling retrieval practice acticities [*sic*] was engaging." (Participant V)
	Research	Evidence from research presented during the AP PLC that supports teachers' use of the strategies	"Hearing about definitive research is helpful!" (Participant K)
Briefly describe how the **collaboration** during AP PLC was engaging for you	Active learning	Learning activities in which participates directly interact in the learning process, as opposed to passively taking in information	"It required participation and made me active in the learning." (Participant P)
	Enjoyment	The process of taking pleasure in the activities	"I always enjoing [*sic*] talking with and learning from other teachers, this is somethings [*sic*] that has been sorely missing this year with virtual learning." (Participant E)

Appendix P

Document Analysis of Lesson Elements Developed During the AP PLC Codebook

Theme	Definition	Examples
Retrieval practice	The process of actively calling information to mind rather than rereading it (Roediger & Butler, 2011)	"Tell me everything you remember about the Ottoman military." I will exhaust responses and then ask a question that narrows the focus a bit, without giving away too much detail. And so [*sic*] after we exhaust all retrieval responses, we run through the PowerPoint, stopping at key locations to refresh their memories." "It was easy because all I had to do was copy some questions from old tests. But the key was getting them to study critical old topics and they even got to practice retrieving those again during the test."
Classroom applications	Low- or high- tech instructional practices that incorporate retrieval practice by requiring students to recall what they know from memory	"I've found it very helpful and simple to have the kids brain dump everything down that they remember. " "Provide class time for everyone to make flashcards or a Quizlet."
Complementary strategies	The integration of allowing time to pass between practice (i.e., spacing) and mixing up problem types (i.e., interleaving), which may enhance durable, transferable learning (Yan, et al., 2017)	"Typically start class with 2 AP styles [*sic*] multiple choice questions from old units." "I used to have my review packets organized by type of problem. For our last unit, I copy pasted [*sic*] the problems to jumble it so kids didn't get too comfortable blindly repeating the same steps."

Desirable difficulty	The presence of a considerable but manageable level of challenge while completing a task (Bjork & Bjork, 2014)	"The results were shocking today. Using this practice resulted in BETTER pitch and rhythm accuracy than playing the melody twice as often. Increasing this difficulty for them is really paying off!" "At first, my students complained at not being able to use their notes during the warm-up and exit ticket… Now they're just in the habit of making things harder on themselves because they know it works."

Appendix Q

Semi-Structured Interview Outcome Evaluation Codebook

Construct	Theme	Definition	Example
How the AP PLC influenced teachers' knowledge of retrieval strategies	Intentional	The purposeful and conscientious effort AP teachers made to incorporate the strategies into their classes	"Made me more cognizant of how to make [retrieval practice] more accessible for students in class, you know, more definitive, more concrete, and just more efficient." (Participant I2)
	Complementary strategies	The use of strategically spacing and interleaving retrieval practice among class activities to attempt to enhance student learning	"In the past, I would just always introduce a new phenomenon. Then, move onto the next. And now I am peppering in old phenomenon, to get them to think about that. And then, tying it into the new phenomenon." (Participant I2)
How the AP PLC influenced teachers' self-efficacy for using retrieval strategies	Subtle practice changes	The modest modifications to teachers instructional behavior to incorporate retrieval strategies	"I really appreciated like how, like all the strategies presented make it easy to incorporate it into my classes." (Participant I1)
	Specific activities	A range of low-tech and high-tech classroom activities that promote students to practice retrieval	"I've been using think-pair shares a lot just a quick like okay what are you thinking what do you remember, without looking at your notes. I think it's a good kind of review for them throughout the semester. I also started using like cumulative questions to things over the course." (Participant I2)
	Student studying	The act of students using retrieval strategies when studying on their own	"My confidence [for helping students learn how to study on their own has] definitely increased. Before it was always kind of struggle, this is only my second year teaching AP, and I struggled trying to teach them how to study. I think it's hard to give them the skills to learn. Giving them some of these different like techniques has been really helpful for me to help them." (Participant I3)

How the AP PLC influenced teachers' perceptions of their students' preparedness for AP courses	Specific strategies	A range of skills and methods teachers and students can use to enhance durable and flexible learning	"A new strategy that I found from the PLC is making index cards. I've honestly not used index cards in my class before and I'm like not ashamed I mean, you know, just learning to do it but, when I use the index cards rather than having them just copy the information, they have tools they can use for retrieval." (Participant I5)
	Student growth	Evidence observed by AP teachers indicating academic progress their students made that they attributed to retrieval strategies	"I think that with retrieval that maybe they're resistant, or have some kind of like resistance to thinking about it in the beginning. Maybe because it's harder. But I think that that was far more effective in the long run and was super helpful for the students who were doing everything with integrity. And they noticed that and told me that." (Participant I4)
	Challenges of virtual learning	Practical barriers due to the virtual learning mode of instruction that may have mitigated some of the benefits of retrieval strategies	"You know, in this virtual environment it's hard to tell if they're, you know, looking up answers instead of retrieving, it's kind of hard to tell." (Participant I4)